THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 43. Thursday, December 18, 1930. No. 748.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, or to the Publisher, as the case may be, of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2.

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (4 lines).

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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

Institute of British Foundrymen.

DECEMBER 19.

London Branch:—Annual dinner in London.

Sheffield and District Branch:—Ordinary meeting. "A New View of the Composition and Structure of Cast Iron," Paper by J. E. Fletcher.

Standardised Costing.

The latest bulletin of the American Foundrymen's Association to reach England details a Standard Cost System for Grey-Iron Foundries. It has been originated by the Gray Iron Institute and is recommended for use by the Cost Committee of the Association. The system is based upon the division of the foundry in four manufacturing departments: (1) Melting, (2) moulding, (3) coremaking and (4) cleaning and despatch, plus (if desired) auxiliary departments, carpenter shop (5), pattern shop (6), maintenance (7) and heat, light and power (8). These departments are divided into sub-departments A, B, C, etc., which check up with the assignation numbers in the general costing system. The assignation of account numbers is further classified by reserving 10 to 49 for regular manufacturing departments; 50 to 99 for auxiliary departments; 110 to 189 for overhead; 200 to 299 for revenue accounts; 300 to 399 for asset accounts, and 400 to 499 to liability accounts.

In the departmental accounts, 10 to 99, the first numeral identifies the department and the second the nature of the charge. These are: Direct material (0), direct labour (1), indirect labour (2), fuel (3-1), sand and materials (3-2), miscellaneous supplies and tools (3-3), repairs (7), foremen and clerks (8), share of general overhead (9), fixed charges (9-1), heat, light and power (9-2), and general expense (9-3). The cardinal point in the system is that the entire general overhead must be allocated to the four manufacturing departments and be completely absorbed by them, becoming a part of their departmental overheads. The cost of the metal at the spout is obtained by combining into one total all the accounts from 10-19 for the month and dividing this by the weight of good castings produced. For moulding, accounts 22 to 29 are divided by account 21 (moulding, direct labour), which gives the moulding overhead percentage, which is to be added to individual jobs on the basis of direct moulding labour, or for heavy foundries the total accounts 22-1 (moulding, indirect labour), 23 (moulding sand and miscellaneous supplies and tools), and 29-2B (power) gives the moulding overhead charge chargeable to individual jobs on a tonnage basis. The total is divided by the weight of good castings produced and gives the cost per unit weight.

The cost of coremaking is carried out on the same basis as the moulding for light foundries and based upon direct core labour. For cleaning costs either a tonnage or direct labour can be used as a basis, but an advanced method has been set out, which utilises such subdivisions as sand-blast-hour costs and so on.

We feel that the system outlined is excellent and has reduced guesswork to a minimum. We understand that the recently-formed British Ironfounders' Association is utilising a system which has proved its worth. The German Harzburger Drucksack is also available in England, and we throw out the suggestion that the Technical Committee of the Institute of British Foundrymen should create a section to study all the above recognised systems and publish a British nationally-recognised method for the use of the industry in general.

A Defect Remedied.

We referred in these columns last spring to the new organisation of the British Engineering Standards Association, in which the field of industry was divided up into about fifteen groups, each group having its own Industry Committee representing makers and users, and each group nominating representatives to the General Council. For such a scheme we had nothing but praise, but we felt compelled to draw attention to the inexplicable omission of the iron and steel industry in the grouping scheme. Although sections of industry of minor consequence to the community had Industry Committees, this basic industry was omitted.

Recently a meeting was held to consider this matter, a large number of organisations interested sending representatives, and the proposal for the formation of a group committee for the industry was approved. The B.E.S.A. Council has now acted on this resolution, and an Iron and Steel Industry Committee was formally established. We understand that all iron and steel materials, cast and wrought, will come under the Committee, and the satisfactory outcome of this state of affairs is in considerable measure due to the representatives of the foundry side.

To appreciate the need for this Committee, it is only necessary to remember that the other Industry Committees (such as Automobile, Aircraft, Gas, Water and so on) can call for iron and steel specifications, and these are mainly users. If we are to produce economically it is essential that the industry *as a whole* should have an opportunity of co-ordinating these and prevent the indiscriminate specification of a multitude of grades of material and methods of testing or test-pieces. Furthermore, a few carefully compiled national specifications might supersede all the specifications issued by railway companies, consulting engineers, local authorities, and this can best be done through an industry committee.

Finally, it is necessary to bear in mind that it is not a question of whether we shall have such a committee or not. As at present arranged, the various committees of the B.E.S.A. which deal with iron and steel are distributed through the present industry committees. Thus the cast and malleable and pig-iron committees are attached to the Mechanical Industry Committee, where they are, again, largely at the mercy of users. With a separate Iron and Steel Industry Committee these are all gathered under one umbrella, and are capable of initiating a policy respecting specifications which shall have proper regard to the point of view of the manufacturer.

XUM

A French Foundry Rationalisation Scheme.

In 1929, the Société Général de Fonderie was formed, with a capital of £410,000, to amalgamate a blast-furnace concern, with two works, and eight light-castings companies, possessing 16 foundries, by obtaining a controlling interest in each. The blast-furnace concern is the Hautes Fourneaux de Saulnes, which has five blast furnaces at Saulnes and two at Hassigny. The light castings firms in the amalgamation are the Etablissements Chappée with foundries at Antoigné, Port-Brillet, Amboise and Dax; Chaffoteaux (St. Brieuc); Maury (Evreux and Paris); Noyon (Noyon); Fils de A. Piat (Aubervilliers, Paris and Soissons); Nanquette (Glacy, St. Michel and Argenteuil); Caloria (Louviers); and Dupont (Le Cateau). With the exception of a line of pulleys made by Piat, the whole of the production of the combination comes under the British classification of builders' castings.

The object of the Société Général de Fonderie is not to play the rôle of a holding company, but rather to effect a unification of management by creating a general overhead service in a central office located at 6, rue Cambacérès, Paris. This office controls the whole of the commercial side of the affiliated companies as well as the various sales depôts. It is interesting to note that the monthly turnover has risen from 5½ million francs in January, 1929, to 24½ million francs in October this year. Moreover, in addition to acting as banker, it has taken charge of the costing of the individual foundries. Other departments controlled from Paris are those connected with the buying of raw materials, legal work and publicity, whilst research has been initiated in enlarged laboratories at Mans.

Newcastle Foundrymen Visit Works of the Bede Metal & Chemical Company, Limited.

A very interesting works visit was paid to the Bede Metal & Chemical Company, Limited, on November 29, by members of the Newcastle Branch of the Institute of British Foundrymen, by kind permission of the directorate. A short *résumé* of the process is as follows:—Copper pyrites mined in Spain is sent to sulphuric-acid makers. After being burnt, the cinders are returned to the company. The composition of the copper pyrites is:—Fe 42, S 48 and Cu 2 per cent., with 2¼ ozs. of silver per ton. The composition of the cinders is:—S 4, Cu 2.5 and Fe (as oxide) 56 per cent., with 2¼ ozs. silver per ton.

The cinders are mixed with 11 per cent. of NaCl and ground to pass ⅛-in. mesh. They are then calcined in 5 bed Ramen-Beskow furnaces at red heat, which changes the copper to sulphate and chloride and the silver to AgCl. The hot ore is moistened as it falls from the conveyor, thus being rendered much easier to wash.

Leaching.

The ore is loaded in vats with filter bottoms and washed with water and weak acid. The copper is nearly all taken out by this liquid. The ore is removed from the tanks after the copper is extracted, is briquetted and sold to iron and steel works, its contents being 65 per cent. Fe. The copper liquor is next desilverised by the following reaction:—

$$AgCl+NaI=AgI+NaCl.$$

The AgI, being insoluble, settles at the bottoms of the tanks, is collected, changed to Ag_2S, and iodide recovered and used again in cycle. The copper is precipitated in large vats by using old scrap iron. The scrap iron is dissolved and 75 per cent. copper remains. The copper precipitate is smelted, refined and sold as ingots, cakes, etc.

Catalogues Received.

High-Frequency Furnaces. — We have received from the Stobie Steel Company, Limited, of Dunston-on-Tyne, a 4-page leaflet, which carries a number of succinct statements telling of the nature and potentialities of this new type of furnace, which eliminates both crucible and electrode costs. Two excellent illustrations show the furnace to admit of extreme ease of working, whilst exhibiting real adaptability for metallurgical uses.

As the furnace presents many novel features, we recommend our readers to accept the offer of the issuing house to avail themselves of the offer of a copy gratis.

Machining Alpax. — Messrs. Lightalloys, Limited, St. Leonard's Road, Willesden Junction, London, N.W.10, in a well-illustrated 20-page brochure have presented to the machinist a veritable text-book on how to machine Alpax—the well-known aluminium-silicon alloy. Amongst the operations dealt with are turning, sawing, drilling, reamering, thread cutting and milling. The balance of the book covers studs, boring-bars, finishing and files. The lubricant recommended is a solution of spirits of wine with 38 per cent. water, with soft soap in the proportion of 1 to 1. Though this is postulated when dealing with reamering, we presume that it applies to other machinery operations also.

We commend the enterprise of this firm, and suggest emulation by other sections of the foundry industry.

Plant and Machinery for Foundries.—We have received through Messrs. John A. Smeeton, Limited, 15, Victoria Street, London, S.W.1, a new edition (H) of the very comprehensive catalogue issued by the Badische Maschinenfabrik, of Durlach. The catalogue is divided into the following four main sections:—(1) Foundry furnaces and accessories and drying plants; (2) sand-mixing and preparing plants and machinery for the recovery of furnace and foundry residues; (3) moulding machinery and appliances; and (4) casting-cleaning plants, such as sand-blast equipment, tumbling barrels, grinders and dust-exhausting outfits.

Space does not permit the detailing of all the machinery covered in this catalogue, but it should be understood that, in general, no supplies such as shovels, bellows and core compounds are included. Thus there are no less than 150 pages devoted to pure equipment. Many of the machines listed are unique, such as those used for the wet cleaning of castings and pneumatically-operated sand-jet moulding machines. The catalogue is excellently illustrated, well indexed and prints a code for the simplification of telegraphic business. The covering letter does not say whether free distribution to our readers is offered, but we feel sure that it is readily available to responsible foundry officials. Recipients certainly can count themselves fortunate, for apart from the intrinsic value, there is a good deal of up-to-date useful technical information.

On December 9, Messrs. R. A. Lister & Company, Limited, of Dursley, entertained a very large party at the Café Royal, in London, on the occasion of their usual annual dinner in connection with the Smithfield Show. Mr. C. Percy Lister presided, and Miss Margaret Bondfield (Minister of Labour) was the principal guest. Proposing the toast of "British Industry," Miss Bondfield made some remarks on the position and prospects of agriculture in this country, and congratulated Messrs. Lister & Company on their excellent record during the past twelve months, in spite of the severe industrial depression. The chairman, replying, referred to the alliance the firm had recently effected with Messrs. Ruston & Hornsby, of Lincoln, remarking that the extensive organisations of the associated firms overseas were now at the disposal of each. It may be added that Messrs. Lister and Ruston & Hornsby have been exhibiting at the Smithfield Show at Islington, their products covering a wide range of petrol, paraffin and crude-oil engines.

Random Shots.

The vagaries of public taste have never been better illustrated than in the case of Chevalier (Maurice, alas, not Albert). Maurice is a gay and light-hearted warbler who would be the last to pretend to greatness as a singer or emotional range and depth as an actor. He performed in London some four or five years ago in the ill-starred revue "Whitebirds" at His Majesty's Theatre. This was one of the most sensational theatrical flops in history, for about £30,000 was spent on the show and it ran only a few nights.

* * *

A couple of acceptable talkies, starting with the "Love Parade," and when Maurice arrives in London the station is rendered impassable by the movie fans. He collects £4,000 a week for two weeks at the Dominion Theatre, and his producer gets almost as much for his pains. The truth is that the women, who form the bulk of our theatre and cinema audiences to-day, have taken to him, and it is perhaps useless to look for rhyme or reason in that sort of fancy.

* * *

We all go to the movies occasionally. The cinema was one of the few places left within easy access of the centre of a town where one could get darkness, quietness and peace. The talkies have changed all that. No longer is it possible to go to sleep without arousing the curiosity of strange neighbours. The children don't like it (they can no longer make a noise during the performance at children's matinées because they would lose the thread of what is being said), and many adults don't like it. But I suppose we shall, as usual, go on putting up with it. We generally do.

* * *

The talkies have eliminated what one can only call the "dumbies." The screen has this advantage over the stage, that it can, without inconvenience or inconsistency, roam or even hop from China to Peru. The silent films took full advantage of this possibility. Too much, for no film was without a chase of some sort. But in a talkie the whole scene can take place on the seventeenth floor of an apartment house; the consequence is that it often does, and the supreme asset of the screen—action and movement (well illustrated by the success of Mickey Mouse)—is sacrificed for a static talk. And we can all talk; all hear talking. The theatre can do that. In these days of Shaw, the Russian dramatists and social comedies, it does it.

* * *

After all, we have Parliament, the wireless, the boss and the wife, and many of us go to the pictures to get away from the lot of them. Contradict me if I am wrong, of course. The talkies give us the same thing over again and our ear drums work overtime.

* * *

Of course, there is noise and noise. And a cheerful noise is often acceptable. At one time we were lulled to sleep by orchestral music. Now it is canned. The result is really tragic. Something ought to be done about it. Flicker Alley is no more.

* * *

I am going to start a society, "The Dumb Film Fiends League," for the support of cinemas giving silent films and music instead of shouties and gramophone records. Perhaps I am conservative. Perhaps I have been bored beyond redemption by "All talking, all singing, all dancing." All at once, no doubt. I gave up my club when comfortable cinemas came in and now I feel done. Don't you agree?

Marksman.

Foundry Apprentice Training.*

By A. E. Berriman.

Having on several occasions been associated with various local committees dealing with education and training in relation to industry, and quite recently sat on a committee appointed by the Board of Education to report on education in the engineering industry, the author has found that the personnel of such committees, including as it does representatives of firms, universities, and other interests, invariably gives rise to a certain amount of confusion of thought, because different people are chiefly interested in different classes of boys.

The Basic Problem.

It is essential, therefore, as a preliminary to any intelligible discussion about education in relation to industry and about the problems of training, to define the class of boy to be catered for. It thus seems necessary to distinguish between at least three classes: (1) The boys who enter industry direct from local schools; (2) boys who have had a secondary or public school education but have not been to a university, and (3) graduates of universities.

Numerically the vast majority of boys in any engineering trade belong to Class 1, and the first and most important point is the appreciation that this class is dependent solely upon local facilities for its education and training.

Thus, the first point of principle is that the apprenticeship problem is primarily a local one, and its national aspect, if any, must be the natural outcome of local action. The tree must grow from its roots up; one cannot create it by beginning with the leaves.

To practical men this doubtless sounds so obvious as to be a platitude not worth saying, but it is doubtful whether the implications of its truth are always fully realised, and certainly they are not always acted upon. The fact that the apprenticeship problem is a local one means that it is up to the firms of the district to solve the problem for themselves. It is useless waiting for a national scheme. It is not even possible, in general, to derive any practical help from schemes existing in other districts, although they may serve to provide useful suggestions as to what can be done.

Recruitment.

The first problem is not so much whether this or that is a good scheme, but of finding the boys, and this is especially true of the present situation in the foundry trade. That is the practical problem in a nutshell, but it is a very hard shell to crack, and those who set out to do this must be thoroughly convinced that the kernel inside is worth having.

Here is the germ of a possible solution in the simple statement of the case. It is essential that the apprenticeship should seem worth while to everyone concerned, and the first thing to realise is that very many are concerned and must be satisfied before the result is achieved, the more important of which are: (*a*) The boy himself—his imagination, enthusiasm and ambition must, if possible, be stirred; (*b*) his parents, who must be satisfied that he is going into a job that will last; (*c*) the Director of Education, who is also at the head of the Juvenile Employment Bureau and has a good deal of influence on parents and boys alike; (*d*) schoolmasters of the local schools; (*e*) the departmental superintendents who are responsible for the practical training of the apprentice; (*f*) the managers who are responsible for the general policy of the firm towards apprenticeship, and (*g*) the principal of the local technical school.

* A Paper read before the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen at Coventry, Mr. A. Harley (President-Elect of the Institute) presiding.

A Matter of Publicity.

Now when the case is so postulated all would agree that in one aspect at least it presents a problem in publicity. This is perhaps an unexpected deduction at such an early stage of the argument, but, when examined, human action is tremendously dependent upon the influence of publicity, and if it pays to advertise soap and other household commodities it should also pay to advertise apprenticeship. Of course, not necessarily quite the same sort of advertising, but rather that if one wants apprentices one must create the demand for apprenticeship, and must recognise that it is publicity which does create the demand. In the ordinary course of events this publicity is provided automatically and free of charge by the mere environment of the boy's life. That is to say, he is bound to know something about local industry in an industrial centre, but it does not follow that he is bound to know anything of, for example, the foundry trade in a district where that trade is only one of many. Indeed, it is quite possible that even if he does know anything of it he may have acquired a wrong impression of its possibilities for him.

Now the first principle of successful advertising is that you must have the goods to sell, and this means, "What are you prepared to offer in the way of apprenticeship?" and "To what extent do you want any assistance from the locality?"

A Local Problem.

When stating that apprenticeship was a local problem it was not meant to imply merely that it was the concern of the local firms. So much is obvious to the meanest intelligence. What was meant was that it is, or should be, the concern of the local municipal authority. In so far as the apprenticeship is to include any school work, it will presumably need the co-operation of the local technical college, which is under the jurisdiction of the local education authority, which is, in general, a committee of the city or county council.

Here one encounters one of the most important points which may be an obstacle to effective action unless it is dealt with in a satisfactory manner, and at the right time. The point is this. There is only one technical college to be shared by the boys from many firms, and there can only be one curriculum for them. The principal of the college is responsible for it, but in so far as he is willing to be guided by the advice of the firms, he is dependent upon getting that advice for himself, and he is more than likely to find conflict of opinion which leaves him without any useful contact. The reason for much of this conflict of opinion arises from a failure on the part of the firm to understand the technical difficulties of the college curriculum. There is not merely a technique in teaching, but there is a very definite limitation as to what can be taught within the limited time available. In short, if there is to be effective co-operation between the college and the firms, some kind of procedure must be arranged which will facilitate the expression of a majority opinion and enable it to prevail.

Operating Details.

This leads us directly to the first practical point of organisation, namely, that the firms must provide themselves with a common channel of communication with the college. A committee is indicated, but while an *ad hoc* committee may serve an immediate purpose well enough, the general application of the principle to all the industrial trades of the district obviously calls for some ægis under which these committees can be created and co-ordinated.

In the engineering industry it is apparent that there exists already one organisation, and only one, capable of providing this general encouragement and administrative help. It is the Engineering Employers' Federation, as represented by the local Association. The function of this body is limited to the administration of labour, and before it can take up such a problem as this it is first necessary that it should formally adopt the principle that apprenticeship and its encouragement in all its phases comes within its sphere of action. This is an issue for the local Association to determine, and it is a matter of interest that Coventry has accepted the principle. The local Engineering Employers' Association has, therefore, appointed a series of committees for each of the engineering trades as practised in the district, and every firm interested in any trade is entitled to be represented on the appropriate committee.

A general committee has been appointed to deal with the common problems of policy and to represent the Association in its relations with the City Council. Simultaneously, the City Council appointed a joint committee to deal with the educational and other questions which are within the purview of the local education authority.

It will be recognised that the official interest of the local Engineering Employers' Association, on the one hand, and the local education authority, on the other, should do much to accelerate effective action and to smooth away difficulties which might otherwise arise if the development of trade apprenticeship took place exclusively under the encouragement of isolated *ad hoc* committees.

So far as the City Council is concerned, it is in the nature of a corporate body, and is naturally chary of action unless it feels that it is dealing with some comparable corporate body representing the employers of the industry as a whole.

A Local Certificate.

One of the first advantages which has accrued in Coventry from this preliminary step in organisation is the creation of a City of Coventry Certificate of Engineering Apprenticeship, which will be available to the boys in all the engineering trades who satisfy the conditions of its award.

It is, possibly, the first certificate of practical apprenticeship. Although at the moment no one possesses it, yet, in the course of time it is confidently anticipated that it will be highly prized. And, if it is properly backed up by the right sort of training and education—in other words, if the goods are inside and not all on the wrapper—then the existence of this certificate will be a real inducement to boys to apply for apprenticeship. It is, in any case, the first act of publicity in the evolution of the scheme.

Now, the first reaction of the foundry interests to this proposition is not unnaturally—"While this may be a fine thing for the engineering trades, how is it going to help us?" The answer to this is first that the foundry trade is one of the engineering trades, and, secondly, that it has everything to gain and nothing to lose by being able to offer its apprentices the same certificate as other apprentices will have. The certificate will, of course, be fully endorsed with details of the apprenticeship so that there cannot be any mistake as to the training which the apprentice has received; equally it raises no question of inferiority or superiority of status. The City Certificate, like the University degree, may be awarded in any of several different subjects, but it possesses a common significance and a uniform value for all.

Publicity Activities.

Thirdly, the scheme leaves the foundry trade, in common with any other trade, complete freedom to advertise itself within the scheme, and the foundry firms of Coventry have already availed themselves of this by issuing their own leaflet setting out the advantages of foundry

apprenticeship. It has also been mooted whether at a later date they might not prepare a still more attractive brochure with photographic illustrations of the various foundries in Coventry. These leaflets are attached to the leaflets relating to the scheme itself, and distributed to applicants principally by the chief education officer, who has expressed himself strongly favourable to the scheme as a whole, and has implied that it will appreciably influence the extent to which he recommends boys to apply for apprenticeship. If this does not attract the necessary number of suitable applicants, then it will be for the Foundry Committee to give further consideration to this part of the problem.

Probationers.

As to the problem of class work, it is necessary to emphasise what should be most obvious but is, nevertheless, often overlooked, namely, that classes cannot be held without the attendance of the boys, nor can they be satisfactory without a suitable teacher, who combines the necessary knowledge of his subject with the ability to teach it. It is within the province of the Foundry Committee and of the committees representing the other trades, to advise the college as to the curriculum, but in order to give a general lead on certain principles of immediate importance, the general committee has established the outlines of an educational scheme in connection with apprenticeship, which may be briefly described as follows:—

In the first place, a distinction is made between boys who are under and boys who are over the age of 16. The reason for this is that whereas some years ago a seven years' apprenticeship was a statutory necessity for the Freedom of the City, now a five years' apprenticeship is sufficient. Therefore, the apprenticeship proper generally starts at the age of 16, in order that it may finish automatically at the age of 21. Boys under 16 are, therefore, more or less in a probationary state, and the arrangements for them at different firms vary widely. It was necessary, of course, to recognise their existence under the scheme, but not possible to bring them specifically within the apprenticeship proper.

Day-Continuation Classes.

Under the Coventry scheme, therefore, boys who are under the age of 16 may be accepted as probationers with a view to apprenticeship, but there is no obligation on either side to continue with an apprenticeship at the age of 16. Nor is there any obligation on a firm to admit boys as probationers, but, if they do so, then it is obligatory under the scheme for the firm to give these probationers two half days per week time off for attendance at classes to learn English, mathematics, drawing and science.

The reason for making obligatory this granting of leave during the day-time to these boys is that the majority opinion is to the effect that these children are too young for evening class work, and, therefore, that if they are selected for training under the probationership part of the scheme, they must be given the necessary time for study. Continuity of education from the age of 14 is essential if the class work associated with the apprenticeship is to be effective. It is hopeless to expect good results, on the educational side, from apprentices of 16 if they have attended no classes since they were 14.

It will be observed, therefore, that it is a short-sighted view of the problem to suppose that the industry's interest in the boy only begins at the age of 16. If he left school at 14 it is a matter of great importance to the employer to know what he has been doing in the meantime. In so far, therefore, as one wants to control the successful development of apprenticeship in one's own trade, it is necessary to study the problem of the probationer.

Indentured Apprentices.

At the age of 16 a boy is either enrolled as an apprentice under the scheme or he is not. There is no obligation on a firm to enrol any particular number of apprentices, but it is necessary that the boy's name should be registered under the scheme at the offices of the local Engineering Employers' Association if he is to be eligible for the certificate when he finishes his time.

Once enrolled, it is obligatory on the part of the boy to attend the prescribed classes, otherwise he will not get his certificate. It is for the foundry and other trade committees to arrange the details of the curriculum with the college, but the general committee has established as a guiding principle that the appropriate course for the apprentice should be founded on calculations, drawings and trade science. The term "calculations" is used in preference to mathematics in order to emphasise the committee's desire that the boy should be given plenty of opportunity in class to practise the actual calculations of his trade, and the idea is that the firms themselves should provide the college with suitable examples with which the college itself can gradually compile a sort of textbook for each trade. Similarly, in the case of drawings, what is meant is the reading of the actual drawings as used in the trade, and the making of them in so far as it is the practice of the trade to do so.

Industrial Science.

The Trade science class in this course is intended for the teaching of the theory underlying the practice of a trade, and it constitutes the principal novelty and the principal difficulty in the scheme, from the point of view of the college, inasmuch as it requires the services of a teacher who is a practical man with a thoroughly sound theoretical knowledge and the requisite ability to teach. In order to make it easier for the college to get the services of such a man, it is assumed that the Trade science class will in general be an evening class.

The question whether the other classes for calculations and drawings are to be held in the day time or in the evening is a question of extreme importance, and it is one on which the firms concerned must agree to common action if there are only sufficient apprentices to make one class possible. In the present state of opinion it was not found possible to make day classes of any kind obligatory for apprentices, but the committee did recommend that apprentices under the age of 18 should be given one half day a week time off for day classes in calculations and drawings. It was felt that by the age of 18 most ordinary apprentices would have covered the essential ground represented by this part of the course.

Evening Classes.

With regard to evening classes, opinion is increasingly in favour of limiting evening-class work to one evening a week. It is also important to bear in mind that they cannot be run successfully during the summer months for the reason that boys will not attend when they can be out in the open. The result of this is that it takes two evenings a week from September to May in order to provide the same class hours as can be obtained from one half day a week from September to July. Even this amount of time only provides 120 hours during the session, so that if the teaching is to accomplish anything, the curriculum must be kept as simple as possible. A further point to remember is that there is bound to be a certain amount of home work in connection with any course of study, and the evening is the only time for this which is available to the boy.

Practical Training.

With regard to the practical training of the apprentice, the censensus of opinion has been strongly in favour of this being done in the works, and it is for each firm to decide how far the apprentice should receive personal and special instruction beyond the natural instruction which he acquires from his daily work.

The Middlesbrough Scheme.

According to Dr. Ingall, several foundries in the Middlesbrough district have arranged a scheme under which a selected number of apprentices constitute a group which is admitted to practical training in each of the foundries in succession. In order to avoid the undue dissemination of information about the special practice of individual firms, this scheme is limited to boys not exceeding 16 years of age, that is to say, it hardly touches the apprenticeship proper as understood, for instance, in this district. The problem of providing apprentices with opportunities for extending their experience is well worth consideration, but for the moment it was a secondary problem, and it is best tackled at the end rather than at the beginning of the apprenticeship. The author means that if and when a satisfactory apprenticeship system is in full operation and thoroughly established, it might be worth while as a refinement of that scheme to consider whether firms would be willing temporarily to exchange selected apprentices in their last year.

National Certificates.

The next notable point in connection with the apprenticeship scheme as visualised in Coventry is that part of it which provides for the higher education of the more able boy. In this connection there was established after the war, through the joint action of the Board of Education and the Institution of Mechanical Engineers, what is known as the National Certificate in Mechanical Engineering. This certificate can be gained by a three years' course of part-time study, and the higher edition of it is awarded on the basis of a further two years' part-time study.

The fact that this is a national certificate means that it must be maintained at the highest practicable standard. The course is, therefore, planned to occupy two half days per week during the full session. The award of the certificate is, of course, by examination, and the standard is such that a large number of boys who enter the course fail to complete it successfully. For these reasons, the course as such hardly provides what is required for the average apprentice, and it is on this account that the alternative Trade science course was introduced into the Coventry scheme. Nevertheless, the assumption is that all those apprentices who are capable of succeeding in the National Certificate course will be given the necessary opportunity to do so, but this is, of course, a matter for each firm to decide.

In addition to the National Certificate in Mechanical Engineering, there is also a corresponding certificate in Electrical Engineering, and the Institute of British Foundrymen has recently made similar arrangements for a corresponding National Certificate in connection with foundry work. This is undoubtedly a step in the right direction, but the success of the National Certificate depends upon the supply of students, and there is at present only one main source for that supply, namely, the localities in which the foundries are situated. Broadly speaking, only those boys will enter upon the National Certificate course who are already engaged in the foundry trade. To this extent, therefore, the success of the National Certificate course depends upon the establishment of an apprenticeship scheme on a sufficiently broad foundation to provide a sufficient number of boys from whom to select the prospective winners. To suppose that such a thing as the National Certificate in itself will achieve a solution to the problem is to assume that a tree can be made to grow from the top.

Secondary School and University Entrants.

It is for the founder to consider what use, if any, he can make of boys who have had this kind of education, and what steps, if any, he is prepared to provide for their suitable training. This is a question apart from the main problem of ordinary apprenticeship, but it is nevertheless a question of some importance, for the reason that if one believes in education at all, one must believe that the best product of the university, for example, does possess a mental equipment which goes beyond the scope of the part-time course. It is not for one moment suggested that the possession of brains, whether of an academic quality or otherwise, is in any way restricted to any particular class of boy. On the contrary, it must be quite evident to anyone who studies the lists of university successes, that they are attained indiscriminately by boys from every social class, and every kind of school. What it meant is that the present range of scientific knowledge has gone far beyond the scope of the evening-class curriculum followed by the ordinary apprentice.

The Difference.

A university provides anything up to 1,000 hrs. per session, which means round about 3,000 hrs. in a three years' course, and it is simply impossible for the average apprentice to cover the same field of study on a spare-time basis. Of course, many exceptional individuals have attained academic distinction entirely by spare-time study, but in general it must be admitted that the whole concept of the university and the process by which students go there presupposes that those who succeed represent the principal national supply of highly-educated brain power. Industry is becoming more and more scientific in its detail and development, and, therefore, more and more dependent upon scientific knowledge and habit of thought on the part of certain individuals at strategic points in the industrial cycle. If these men are to be effective it is essential that they should have a sufficient comprehension of the practical side of the work that has given rise to the problems which are submitted to them. This means that they should be encouraged to go through a suitable course of training as soon as they leave the university.

It is for each department of industry to decide what it is going to do about that. Clearly it is only a question of admitting one or two such men at suitable intervals in order to provide sufficient candidates for such vacancies as may reasonably be anticipated. But even doing this much means a decision of policy and the starting of a definite scheme.

Secondary School Entrants.

The case of the secondary schoolboy is rather difficult. In so far as he is a local boy and therefore able to live at home, he can be brought within the scope of the apprenticeship, provided that the firm is not prejudiced about his age and is, in fact, willing to give preference to his application.

Under the present system of education in this country, schoolboys everywhere work for the Ordinary School Certificate at the age of 16, and most of them leave school at this age, although some stay on for a further two years in order to get the Higher Certificate by specialising in certain subjects. On the whole, therefore, it is probably advisable for firms to require the possession of one or other of these certificates as evidence of educational ability corresponding to age and as a qualification for admission to apprenticeship direct from school at that age.

It will be observed that the encouragement of secondary schoolboys eliminates all the problems of probationership. Also such boys should have a very much better equipment with which to succeed in the National Certificate course, and in so far as the standard of this is high enough for most of the jobs which are available in the trade, it may be said that the case of the secondary schoolboy is especially worthy of consideration.

The case of the boys from public schools, whose homes are outside the district, is somewhat more difficult; inasmuch as it is expensive to live away from home, and the probability is that the parents are not in a position to bear the whole of this expense. If the firm is to provide more than the normal apprentice rate of pay for any special trainees, it will naturally consider whether it will get the best value for money by encouraging university men or secondary schoolboys, and where the choice falls on the product of the university, the secondary schoolboy, from a distance, is left out in the cold. This is a practical aspect of the difficulty which must be settled by each firm as it thinks fit.

The questions to which each member of the industry should address himself in any discussion are:—(1) Do you want more boys? (2) do you want to train them? (3) do you want the assistance of the Technical College? (4) do you want them under the age of 16? (5) if not, what are you going to do about it? (*a*) are you going to accept probationers as a matter of principle in order to avoid the educational gap? or (*b*) are you going to specialise in the secondary schoolboy? (6) are you going to give your apprentices time off for classes? (7) do you approve the idea of a Trade science course specially adapted to provide effective tuition for all boys of *average* ability, and a national course of the highest practicable standard for the best boys only? (8) do you consider that any of your technical problems attain to what the author terms a university degree of difficulty, and, if so, what are you going to do to provide yourself with that class of assistance? and (9) do you approve the idea of a certificate of practical apprenticeship to be awarded to every apprentice who completes an apprenticeship which is satisfactory to a committee of practical men and includes a course of study which is satisfactory to the Principal of the College?

Eliminating Wasters.

At a meeting held in the offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, W.C.2, on November 28, a Paper on "Foundry Practice" was given by MR. H. G. SUMMERS. Miss M. D. Pittuck (chairman) presided.

The lecturer said he could remember the time, not so many years ago, when one could go into many of the leading foundries in the country and not find a machine of any description, except here and there a gear-moulding machine or a common hand-squeezer. In those days the majority of foundries had to depend entirely upon the skill of the moulder, whereas to-day the craftsmanship of the foundry was lowered as the result of the introduction of machine moulding and labour-saving devices of every kind. He thought the time was not far off, however, when the foundry trade would call for the craftsmen of pre-war days. When this time came, good leadership in the shop would be called for, and it was from the Junior Sections of the Institute of British Foundrymen that the leaders of to-morrow should come.

Jobbing work was a supreme test of the foundryman's ability and called for the highest skill owing to the work being so varied. The reduction of defective castings was a problem of great importance and should command the earnest attention of every foundryman.

One point to be considered, however, was that castings accepted by one company might be rejected by another, and the line differentiating between sound and defective castings was drawn at different points. In this respect nearly every customer was a law unto himself. He fixed what he considered to be a standard for his own requirements.

The cause of most defects was the sand. The sand must be free from lumps, well mixed, tempered, and strictly uniform throughout. Cheap sand was often the most expensive raw material that a foundry could buy.

It was the duty of the foundry foreman to give a little personal instruction to each of his moulders on the correct methods of ramming, venting and finishing a mould.

Keen supervision was also necessary to find out the cause of dirty castings. One heard a lot about dirty iron. It appeared to be the standby of the moulder when castings were rejected by the machine shop.

Swollen or overweight castings were another source of wastage. The foreman must keep a keen watch on overweight castings.

The use of chaplets and studs often gave the foundryman trouble, through their being rusty and causing blowholes in the iron. About the best prevention of this trouble was to have all rust taken off the chaplets and to have them tinned. Apart from eliminating the danger of rust, the affinity of tin for iron was said to make the iron more susceptible to heat. Red lead mixed with turpentine was one of the best paints for chaplets. The best neutraliser of rust of which he (the lecturer) knew was creosote. If a very much rusted piece of iron was dipped in refined creosote and then plunged into hot molten iron the disturbance was hardly perceptible.

Cast-iron chaplets were most suitable where castings required machining, as the molten iron adhered to them better than it did to wrought iron, but care must be taken not to insert the chaplets where the metal would run against them, as they melted rapidly.

It was not always good practice to have chaplets and studs in castings, such as cylindrical ones, which had to be poured horizontally and bored out. Trouble was often experienced in the machine shop owing to hard spots round about the chaplets, due to the chilling of the metal. Also, in the case of acid-resisting castings, which were usually made from high-silicon iron, trouble was often encountered owing to the acid eating away the chaplet.

To produce a good casting it was essential that the metal be hot and fluid. If the metal was cold and sluggish it might mean that the coke bed was too low—a very common error, and one which resulted in porous, weak castings owing to the metal melting directly in front of the tuyere blast and becoming unduly oxidised. Another source of cold metal lay in the attempt to conform to a prearranged melting ratio. There was no such thing as a standard melting ratio for cupola practice. Yet a further source lay in the use of thin, rusty scrap and painted scrap. The oxides from these entered the metal and became emulsified, and no amount of fluxes or deoxidisers would remove the trouble.

In conclusion the lecturer advocated that all new repetition work coming into the foundry should pass through the hands of a highly-competent man. He should be allowed to experiment until he arrived at the best method of doing the job. With a satisfactory method once established and recorded, showing all the important details, it would be immaterial whether the personnel of the foundry changed or not, as the records would always be available for whoever needed them.

An enthusiastic discussion followed.

Steel Structures Research.—Under this title the Department of Scientific and Industrial Research has now published a Report of the Conference held on October 16 last, at which it was unanimously resolved that it would be most valuable to have a standard practice for the employment of structural steel in building, and the Conference trusted that all bodies concerned would take steps to ensure that the results of the work of the Steel Structures Research Committee were effectively applied as they accrued. Copies of the Report (1s. net) may be obtained from the Stationery Office, Adastral House, Kingsway, London, W.C.2.

I.B.F. President Addresses Scottish Founders.

GENERAL SECRETARY EXPLAINS FOUNDRY CERTIFICATES.

A meeting of the Scottish Branch of the Institute of British Foundrymen was held in Glasgow, on December 6, at the Royal Technical College, Mr. James Miller (Branch-President) presiding. Mr. F. P. Wilson, J.P., President, and Mr. T. Makemson, General Secretary of the Institute of British Foundrymen, were present.

Diploma Awarded.

The CHAIRMAN said that it was his pleasing duty to introduce Mr. Wilson, the President of the Institute, who had come North in order to be with them in his official capacity, and he felt sure that the members would, like himself, feel that it was a high honour to have the President at their meeting. He would now ask Mr. Wilson to be good enough to present the diploma, which the Council had awarded to Mr. T. M. Service for the Paper which he presented to the Branch meeting last session on "Steel Castings."

MR. WILSON said that he felt it was a very great honour to be asked to hand to Mr. Service the diploma. He knew that the diplomas were not easily won, and they could take it that any member who did receive one thoroughly deserved it. There was committee charged with the duty of reading every Paper published in the JOURNAL and judging whether it was worthy of being printed in the "Proceedings" or of the award of the Institute's diploma. There were several people concerned in the decision, and their views afterwards came before the General Council for consideration and confirmation. It would, therefore, be realised that the Paper presented by Mr. Service must have been of a very high order to have passed through that scrutiny. He congratulated Mr. Service on presenting such a Paper, and had the greatest pleasure in presenting to him the diploma.

MR. T. M. SERVICE, in acknowledgment, said that he felt very highly honoured that the Council should have awarded him one of the diplomas. When he was asked to read a Paper before the Branch he had no intention of doing anything more than present a useful Paper. He thanked the Council for having awarded him the diploma and the President for the kind words of appreciation he had addressed to them.

The CHAIRMAN said that if Mr. Wilson would like to address a few words to the members they would be pleased to hear him.

Progress of Scottish Branch.

MR. WILSON said that they had to hear a Paper by Mr. Harley on a very interesting and important phase of foundry work. He felt that it would be a pity to take up the time of the meeting to any length, as he would have another opportunity of speaking to them later in the evening. It was, indeed, a great pleasure to meet the Scottish Branch members in their regular meeting place and to take part in one of their ordinary meetings. He appreciated very much the enthusiastic and cordial welcome which they had extended to him.

He had recently, with the help of the General Secretary, been trying to learn some of the history of the Scottish Branch, and found that it was founded 20 years ago, so that this was a notable year. The Branch was started only six years after the British Foundrymen's Association was formed, the name by which the Institute was originally known. In 11 years the membership rose from 45 to 310, but it was found that a number of those members were not particularly enthusiastic, or, at any rate, were not sufficiently concerned to pay their subscriptions, so a few years ago a certain amount of weeding out was necessary. The effect was very evident, as since then the growth of the branch has been continued at a steady rate. Last year there was a net gain of 20. He noticed that the Scottish Branch had on four occasions offered hospitality to the annual conference; in fact, they had offered hospitality before they had a Branch in 1905. Again in 1911, 1920 and 1925 the conference had been held in Glasgow, which showed that there was considerable enthusiasm and interest in the cause of the industry.

The Scottish Branch had given to the Institute one of its greatest benefactors in the person of the late Mr. Mayer, who presented the chain of office and also founded the Surtees medals competition, which was the means of doing excellent work among the young men. In addition to the Branch meetings in Glasgow there was a healthy section in Falkirk which enabled members who could not come to Glasgow to have their meetings for the reading and discussion of Papers. He believed that the Branch had as members many working moulders as well as foremen and managers; they wanted to get them all into the Institute. He had been interested in the syllabus for the session, and he wished to congratulate them upon the excellent programme, which catered for all, or almost all, sections of the foundry industry.

He wished to say that it had been a great pleasure to see the Branch Council at work that day and to learn of the wise steps being taken for increasing the membership of the Branch and for enlisting the sympathy and assistance of firms and employers. He wished the scheme every success and hoped that in spite of the difficulties they were up against at the present time the results would enable the Branch to be more successful than it has ever been before.

Foundry Craft Certificates.

MR. T. MAKEMSON said there were many things which he would like to say to them, but he knew that the Paper was the chief business of the day, and so he would have to confine his remarks to one important development, viz., the award of foundry certificates on a national basis. It had for many years been lamented that the lads in the foundry did not attend classes in foundry subjects, but it was a fact that there had always been some classes which did attract the lads and were well attended. The difficulty was, however, that the certificate which was awarded at the end of the course had only a local or regional value. The examination paper may have been conducted by the principal of the technical school or the local education or other authority, but the fact remained that it had only a local or regional value. The question arose whether the Institute could do something to standardise these certificates so that a certificate granted, say, in Falkirk, would have the same value in Cornwall. He was glad to be able to announce that such a scheme would be in operation next year.

It was felt by the Council that the Institute was hardly the body to conduct these national examinations, and that it would be better to give it to a national body, so the City and Guilds of London Institute was approached with a view of undertaking the conduct of the examinations and the issuing of the certificates. This Institute is a purely examining body and already had the machinery, so that all that had to be done was to graft on an examination in foundry work and in patternmaking. An advisory committee was set up upon which the Institute was largely represented, with representatives of all educational and technical associations throughout the country. That committee had held several meetings in London during the year, and a subcommittee had met in Birmingham. The committee had been very active during the past twelve months, with the result that the scheme was almost complete.

The particulars of the courses and certificates will be circulated very shortly, and next session all colleges and schools will be able to prepare students for the examinations. What would be the benefits? A student attending the classes with the view of obtaining a certificate would be working with a definite object the attainment of which would add to his reputation. He felt that when the scheme was in operation the classes already established would increase in popularity and that others would be started. He hoped also that the plea that the foundry industry was not catered for would disappear. Another class of certificate had been instituted in conjunction with the Institution of Mechanical Engineers and the Board of Education in England and with the Scottish Board of Education in Scotland. Under this scheme colleges may submit syllabuses modified to suit the foundry industry for approval by the board so that at the end of four years' course of university standard a national certificate may be obtained.

The Professional Certificate.

He wanted to emphasise that there were two schemes; the first that he had outlined, a craft certificate, suited to prospective foremen and workmen, and the other, under the Institution of Mechanical Engineers' scheme, of a more professional nature. He hardly expected a large number of students under the second scheme at first. Progress would be slow, they could not turn the foundry trade round all at once, but in time the number of candidates would gradually increase.

It was the duty of the Institute to appeal to firms and employers to encourage the students and to urge their employees to attend the classes for the good of all concerned. He was very glad to have had the opportunity of telling them exactly what had been done in the matter of national certificates and of letting one Branch know what has been arrived at for the improvement of the foundry trade.

The CHAIRMAN thanked Mr. Wilson and Mr. Makemson for attending their meeting and addressing them. He assured them both that the members were deeply appreciative, and, on their behalf, he tendered them their sincere thanks. He then called on MR. HARLEY, of Coventry, to read a Paper on "The Production of an Aluminium Alloy Casting," which will appear in a future issue.

Midland Pig-iron Makers' Rebate Scheme.

The Midland pig-iron producers have formulated a rebate scheme which is applicable only to comparatively large consumers and excludes merchants. The rebate is granted on the undertaking of iron-founders that they will not purchase supplies of imported pig-iron. The rebates are as follow, and the quantities indicated have to be taken over a period of six months :—

Not less than 1,000 tons and not exceeding 1,500 tons	6d. per ton
Over 1,500 tons and not exceeding 3,000 tons	9d. per ton
Over 3,000 tons	1s. per ton

RÖCHLING'S IRON & STEEL WORKS COMPANY, at Völklingen, in the Saar district, report for the past financial year gross profits amounting to 45,040,230 fcs. and net profits to the amount of 13,983,917 fcs. Of this, 11,500,000 fcs. are to be placed to the general reserve fund, 200,000 fcs. to the reserve fund for payment of taxes, 430,675 fcs. will be absorbed by directors' fees, 1,500,000 fcs. in payment of a 15 per cent. dividend (as in the previous year), and the sum of 353,242 fcs. will be carried forward. The company's output of various products is reported as 478,744 tons of coke, 527,426 tons of pig-iron, 427,984 tons of basic-Bessemer steel and 356,285 tons of finished products. In addition to these quantities the Edelstahlwerk Röchling produced last year 81,160 tons of open-hearth and electric steel, 65,740 tons of rolled products, 3,494 tons of forgings and 2,771 tons of springs. The accounts of this concern are kept separately from those of the mother concern. The dividend in this case will also be 15 per cent., absorbing a sum of 300,000 fcs.

Characteristics and Utilisation of Nottinghamshire Sands.*

By F. Hudson.

It has been the author's privilege for the last 15 years to work in very close contact with the practical side of foundry work, and, in particular, with those illusive causes which make castings bad. At one time he thought that the majority of defective castings were caused through bad metal or poor pig-iron, due, possibly, to the fact that he knew nothing about foundry sands, and that the more practical of his associates knew everything worth knowing. It is a very true saying, however, that "The more knowledge one gets, the less one knows," and now he is convinced that a study of sand, basic material of the trade, is of very great importance.

In one case which comes to memory, where trouble occurred through the scabbing of green-sand moulds, the opinion at the time was that the sand was too weak in bond. To improve the bond it was decided to add more new sand and omit any other alteration to such factors as time of mixing, moisture content, degree of ramming, percentage of coal dust, etc., as it was felt that additional troubles, due to the sand being too close, might then arise. To cut a long story short, the addition of the extra new sand gave less bond than ever, and the increased bond was finally obtained by the addition of sea sand. The new sand used in this instance belonged to one of the best natural deposits, namely, Erith.

FIG. 1.—SHAKING MACHINE USED FOR WASHING CLAY FROM SANDS.

Why the addition of material, having no bond in itself, should increase the bond of a green-sand mixture is, perhaps, puzzling, but, nevertheless, true, when certain other conditions are also present, and later on the answer for this will be demonstrated.

To cite another example of more than usual interest, it has lately been found in the author's laboratory that a certain loam mixture in use by a large foundry on the North-East Coast evolves a really serious amount of gas on casting. In fact, the amount of gas evolved was considerably in excess of that given off by any oil-sand core. The best loam made has only one-twentieth the permeability of oil sand, so it is obvious that a set of conditions exist which are not conducive to the safe production of castings. All moulding sands give off gas when heated, no matter how perfectly they are dried, and the volume of gas evolved varies considerably in different deposits. Furthermore, the gas is in most cases odourless and invisible. Many core-makers in the past have been blamed for blown castings, when the gas evolved from the sand has been the real root of the trouble. To take another recent experience, this time in regard to sea sand used for oil-sand cores. A complaint arose that the quality of a certain core oil was depreciating, as it had been found necessary to use an extra half-part in each mix. No alteration had been made in either the composition of the oil or in the core-shop practice. Ultimately, the sea sand used, which, by the way, was Southport, was found to contain 5 per cent of clay and silt, and this clay was causing friable cores. On using clean sea sand the trouble disappeared. The defective core sand, to all outward appearances, was up to normal standard. However, at this time, it is only desired to give those examples to show how little is really known about sand, and how an increased knowledge may prove the key to increased efficiency.

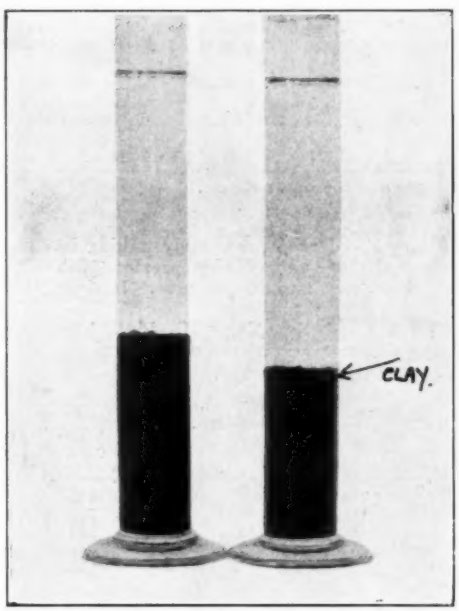


FIG. 2.—VOLUMETRIC PERCENTAGE OF CLAY OCCURRING IN SOUTHPORT SEA SAND.

The true answers would never have been obtained without the use of sand-testing apparatus and control. Too many consider that because there are natural deposits in Britain of presumably excellent foundry sands, there is no need for the use of sand-testing apparatus and systematic control. Personally, the author would unreservedly prefer to work with the synthetic moulding sands, such as are used in the United States, prepared and standardised by scientific methods, than use the natural deposits of this country without scientific control. The controlled synthetic sand will produce the minimum of defective work.

It is essential that founders learn more about sands, and the sooner more attention is paid to this subject, then the better for the industry. It has been said that the price of safety is eternal vigilance. Of all industries, surely this applies to the art of founding more than any of the others. At the present time there is a great shortage of workers in this field and a paucity of information of practical value.

In dealing with the sources of foundry sands of Nottinghamshire the task is simplified by the fact that they are not varied. In fact, the majority of deposits in the Midlands conform to what is known as the Bunter sands, of which Mansfield is typically representative. It will thus be possible to give a more detailed outline of the physical properties of the sands, particularly affecting practical application. At the same time, however, an attempt will be made to show how the local sands compare with others from different districts. Perhaps first it will be advisable to outline the sand-testing apparatus used. This has already been more or less fully described in a previous Paper.* The main modification in the equipment used is the incorporation of a system of washing the sand before conducting the sieve test and the adoption of mechanical equipment for obtaining the dried strength tests for tensile and transverse.

Sieve Test.

In the determination of grain size for moulding sands, the presence of clay usually makes the silica sand grains appear larger, due to this clay acting as an external coat to the grain. To obtain the true sand grain size this clay or bond must be removed by washing and the sieve test conducted on the washed sample. By comparing the result obtained after washing against an unwashed sample, a relative idea can be obtained as to the thickness and distribution of the bonding matter. The washing method adopted is that used and recommended by the American Foundrymen's Association as follows:

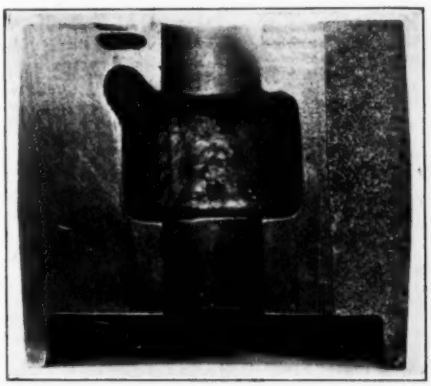


FIG. 3.—SHOWING DEFECTIVE CASTING, DUE TO BLOW-HOLES FROM OIL-SAND CORE.

"One hundred and fifty grams of moulding sand correctly dried are put into a quart preserving jar, smooth on the inside, with no sharp shoulders in the neck, to permit the sand to be easily removed with a small stream of water. [The author uses milk bottles.] Four hundred and seventy-five cubic centimetres of water and twenty-five cubic centimetres of a standard solution of sodium hydroxide (made by dissolving 10 grms. of sodium hydroxide in 1,000 cubic centimetres of water) are added and the bottle securely corked with a rubber bung. The bottle is then placed in a shaking machine such as shown in Fig. 1 for a period of 1 hour. At the end of one hour the bottle is removed, unsealed and the sand adhering to the cork is washed into the bottle. The bottle is then allowed to stand for 10 minutes and the water siphoned away by means of a tube extending to about 1 inch from the sand. More water is added, permitting the stream to stir up the contents, and after standing 10 minutes is again siphoned away. This is repeated at further five-minute intervals until the water remains clear at the

* A Paper read before the East Midlands Section of the Institute of British Foundrymen, Mr. T. Goodwin presiding.

* FOUNDRY TRADE JOURNAL, April 12 and 19, 1928; February 21, 1929; December 19 and 26, 1929.

end of the five minutes. By this means the clay substance is separated from the grain. The grain remaining in the bottle is washed on to a filter paper, drained, dried and weighed. The difference in weight represents the clay substance. The dried sand is then used for the sieve test."

Table I.—*Fineness Tests on Nottinghamshire and Other Sands.*

	Passes mesh, per cent.								Per cent.	Per cent.
	20	30	40	60	80	90	100	120	Clay.	Sand.
Bromsgrove Red	99.80	99.6	99.1	93.0	80.8	75.7	65.6	61.6	7.03	92.97
(Bromsgrove Sand Co.)	*100.0	97.7	95.0	82.2	64.0	61.3	48.5	44.2	—	—
Mansfield Red	99.9	99.4	99.1	97.4	94.3	91.7	85.4	81.2	3.53	96.47
(Mansfield Sand Co., Ltd.)	*99·0	96.0	93.7	89.1	83.4	81.3	72.5	68.5	—	—
Stourbridge Red	99.9	98.6	96.9	90.3	80.1	77.2	66.2	59.4	5.00	95.00
(Parkes & Hill, Blackheath)	*99·8	94.2	90.3	75.3	58.7	55.8	45.1	41.1	—	—
Stourbridge Red (milled)	99.8	99.3	98.8	93.7	85.4	82.7	72.6	67.7	16.00	84.00
	*99.6	93.6	86.0	65.1	49.3	46.4	33.4	30.2	—	—
Bramcote Medium Red	99.8	99.1	98.4	95.0	91.4	87.6	81.6	78.4	14.00	86.00
(General Refractories, Ltd.)	*99.5	95.6	90.5	78.9	69.7	66.4	58.7	55.5	—	—
Dale Yellow	99.7	98.9	97.6	70.8	48.7	46.6	35.7	30.3	9.26	90.74
(General Refractories, Ltd.)	*99·6	96.0	90.1	57.3	38.6	33.6	25.2	20.9	—	—
No. 59 Sand (General Refractories, Ltd.)	99.8	98.9	97.6	90.5	80.4	73.9	55.5	50.0	6.30	93.70
No. 60 Sand	99.6	99.1	98.7	97.7	95.2	93.4	86.4	81.2	6.09	93.91
(General Refractories, Ltd.)	*99·2	96.7	95.2	88.5	74.6	67.9	55.2	49.5	—	—
Bromsgrove Silica (Bromsgrove Sand Co.)	99.4	94.8	82.1	49.2	29.4	28.1	16.5	13.5	1.04	98.96
Maximum Core Sand (General Refractories, Ltd.)	98.5	90.6	62.9	22.2	9.9	8.7	4.9	4.2	0.56	99.4
Southport Sea Sand	99.8	99.6	99.2	94.7	22.7	19.4	3.9	1.0	Nil.	100.00
Leighton Buzzard Sand, No. 6	93.7	70.1	29.1	3.5	1.0	0.9	0.5	0.3	Nil.	100.00
Erith Loam (medium)	98.2	96.9	95.7	94.2	92.9	92.8	91.0	90.3	14.42	85.58

Stourbridge Red Sand milled for 15 minutes at 9 per cent. moisture.

* Sieve test conducted without washing sand.

Breaking Dried Tensile and Transverse Test-Pieces.

The time taken to apply the full breaking load is very important in this phase of sand testing. The faster the rate of load application, then the higher strength figure obtained. All results given in this Paper were obtained by fast loading. The time of first load application to fracture was between 30 to 60 seconds.

Sieve Tests on Nottingham District Sands.

Table I gives the results obtained on the sands tested. The majority of the sands have been tested before and after washing, and it is interesting to note the large difference in grain size obtained by the two methods. For convenience the sand grain size obtained after washing will be termed the "true" grain size, whilst the size of grain on the unwashed sand will be called the "apparent" grain size. Another very interesting point comes to light relative to the results obtained on Stourbridge sand before and after milling. It will be noticed that the sieve tests conducted on the washed samples show 59.4 per cent. to pass a 120-mesh sieve before milling, whilst 67.7 per cent. passes a 120-mesh sieve after milling in a light pug mill for 15 min. at 9 per cent. moisture. This shows that the silica base sand grain has been definitely *reduced* in size. Comparing the same samples before washing, it will be noticed that 41.1 per cent. sand passes a 120-mesh sieve, whilst after milling only 30.2 per cent. passes a 120-mesh sieve. In this case the sand grain has been apparently *increased* in size. The true result is, of course, that, whilst the milling has definitely reduced the size of the silica grain, it has also resulted in a distribution of bond over the grain surface, and accordingly made the sand grains appear larger than they really are. Considering these results with the physical tests given in Table II for the same sand, it will be noticed that the effect of milling has:—(1) Resulted in an approximate increase of 61 per cent. in green-bond strength at 7 per cent. moisture; (2) the green sand is 17.6 per cent. less permeable at 7 per cent. moisture; (3) the dried transverse strength is increased by 45 per cent.; and (4) the dried sand is 18 per cent. less permeable.

Before any dogmatic statements are made concerning the efficiency of any sand-mixing or preparing machinery or equipment, it is essential to consider the full facts given above by conducting the tests on a trial mix. In this particular test, the mill definitely crushed the sand and too much bond is present. It should also be noticed that presumably milling has increased the amount of clay present (Table I) from 5 per cent. to 16 per cent. It should be clearly understood that this increase may not be entirely due to milling, as sand as received from the quarry contains the clay bond irregularly distributed, and the figure of 5 per cent. represents the percentage of clay on a small sample. Milling certainly distributes the clay bond more evenly, and so a more true figure of the actual clay percentage is obtained. At the same time, the presence of fines due to crushing will tend to increase the figure for the clay percentage. Nos. 59 and 60 are from the Warsop district.

One often asks which is the best sand-preparing equipment to use. This question cannot be answered without taking into consideration the condition of the sand as received. For instance, some sands, such as the Scottish Rotten Rock class and a few of the red Bunter sands of the Midlands, come from the quarry in lump or partial lump form. These must first be crushed in a pan mill and then the clay bond must be distributed effectively around each sand grain by a suitable form of intensive mixing machine or special mill. In this case the operation resolves itself into two distinct stages—crushing down to correct size—distribution of bond. The size of sand grain obtained in the first stage depends on many factors, such as:—(1) Size and weight of rollers; (2) speed of roller revolution; (3) time of crushing; (4) depth of sand beneath rollers; (5) effective pressure applied to sand; (6) degree of moisture present; and (7) strength of sand grains (resistance to crushing).

In regard to the second stage of bond distribution, this requires, for 80 per cent. of the moulding sands used in this country, the employment of an intensive mixing action in conjunction with moderate pressures, to ensure no further reduction in sand grain size. The 20 per cent. of sands making an exception to this statement are those requiring the addition of a very "fat" clay such as Cornish clay, commonly used for synthetic steel sands. The foregoing remarks apply to the preparation of foundry sands containing lumps of rock-like material. In those cases where two sands must simply be mixed together, then the question resolves itself simply into the employment of an intensive mixing

Table II.—*Physical Tests on Nottinghamshire and Other Sands.*

Name.	Per cent. moisture	Tested green.		Tested after drying for 1 hour at 400 deg. Fah.				Remarks.
		Green dropping test. In.	Perm. (secs.)	Tensile. (Lbs. per sq. in.)	Transverse.	Perm. (secs.)	Gas evolved (cub.ft.)*	
Bromsgrove Red	7	2.8	103	43.7	7.1	185	—	After heating sand to 1,200 deg. C., colour changes from red to greyish green. Considerable "fritting" occurs.
	12	2.56	140	60.25	12.1	376	1.80	
	17	2.3	829	62.0	15.3	650	1.20	
	21	—	—	44.0	10.1	2,580	—	
Mansfield Red	7	2.47	124	27.0	3.9	158	17.7	As above. "Fritting" worse.
	12	2.27	153	59.0	9.0	269	21.5	
Stourbridge Red—								
Not milled	7	2.66	92	15.0	3.1	169	—	Note difference in gas evolved before and after milling. This is due to uneven distribution of organic matter.
	12	2.57	129	48.0	8.4	344	2.50	
Milled	7	4.30	108	38.5	4.5	199	16.70	
	12	3.23	258	100.0	18.9	831	14.10	
Bramcote Medium Red (milled)	7	3.43	118	—	—	—	—	As given for Bromsgrove.
	12	2.77	163	73.0	11.6	515	4.61	
Dale Yellow	7	2.29	80	—	—	—	—	Considerable "fritting" occurs. Colour changes to grey.
	12	1.91	157	58.0	11.25	292	4.30	
No. 59 Sand	7	2.36	97	—	—	—	—	As given for Bromsgrove.
	12	2.08	114	42.0	7.65	223	2.30	
No. 60 Sand	7	2.68	124	—	—	—	—	As given for Bromsgrove.
	12	2.51	160	52.0	10.7	265	2.00	
Erith Loam (medium)	12	3.56	342	12.0	0.76	402	3.30	Severe "fritting."
	18	5.00	1,224	45.0	7.47	925	—	Vitrified.

* Gas evolved from 1 cub. ft. of dry sand on heating to 1,200 deg. C. for ½ hour.

Note.—The lower the permeability figure given, then the *more* permeable is the sand. The permeability figure is the actual time taken for a definite volume of air to pass through a definite section of rammed sand.

machine which will effectively distribute bond without causing reduction in grain size.

Physical Tests of Nottingham Sands.

The physical tests obtained are illustrated in Table II. It will be noticed that they have been tested at 7 and 12 per cent. moisture contents, typical of the degrees of moisture usually used for green- and dry-sand moulding respectively. The percentage of moisture present has an important bearing on the physical tests obtained from any one sand. Considering Bromsgrove Red Sand, it will be noticed that as the moisture content increases above 7 per cent. the (1) green-bond strength decreases, (2) green sand becomes less permeable, (3) dried bond strength increases to a maximum figure around 17 per cent. moisture and then decreases, and (4) dried sand becomes less permeable.

The reduction in dried bond strength after 17 per cent. moisture is reached is probably due to the formation of drying cracks. It will be noticed that the sand containing 7 per cent. of moisture is approximately 14 times more permeable than the same sand containing 21 per cent. moisture. This sand has not been milled and the difference in permeability is entirely due to the increased moisture content. It is obvious that in drying loam jobs, extreme care must always be taken to ensure slow drying. In the present example the permeability was such that, no matter how slow the drying, the formation of cracks occurred, which weakened the strength of the sand.

The correct amount of water to use for any sand depends essentially on the nature of the sand and the type of moulding practice adopted. For instance, for green-sand moulding the requirements for safe working are ample green bond, consistent with maximum permeability. The percentage of moisture required to develop maximum green bond varies according to the nature of the sand and the amount of clay or bonding matter present. For example, a green-sand mixture made up from Bromsgrove Red develops maximum green-bond strength with a moisture content of approximately 5 to 7 per cent., whilst the maximum green bond developed from, say, medium Erith loam requires the presence of at least 18 per cent. moisture. As a general rule, it can be assumed that the finer the sand and the more bond present, the more moisture is needed to develop maximum green-bond strength. Straight Erith loam as tested in Table II has practically no appreciable green-bond strength at 7 per cent. moisture. It is too dry to work. However, if a definite percentage of a silica sand, such as sea sand, be added, then a reasonable green-bond strength is developed at 7 per cent. moisture, whilst the sand is more permeable and the resulting sand mixture infinitely more suitable for foundry work. The addition of the silica sand performs two distinctly important operations: (1) Concentrates the moisture present in the bonding sand, namely, Erith, so allowing maximum bond to be developed with reasonable moisture content (whilst the sand as a whole contains, say, 7 per cent. moisture, the actual moisture in the clay bond may reach considerably higher percentages), and (2) makes the sand more permeable.

This example demonstrates the fact that to obtain the best from moulding-sand mixtures, a correct knowledge of blending can only be obtained by a careful and full study of the physical properties developed by sands. A long Paper could be written on all the interesting points brought to light in Table II, but to the careful observer they become obvious after a little study. The only other point requiring immediate mention is the gas evolved from different sands on casting. It will be noticed that the gas evolved from the sands tested varies from 1.2 up to 21.5 cub. ft. These figures, studied in conjunction with permeability and moisture content, are of very great practical value.

To obtain the full benefit of the tests illustrating the physical properties of Nottingham district sands, it is more or less essential to have some definite idea of the physical properties required of sand to produce good castings. In this respect the author suggests in Table III the following rough requirements, as tabulated herewith.

In conjunction with the above, the sand, when cast, should be easily removable, and should preferably contract. All the sands tested in Table II were harder and stronger after heating to 1,200 deg. C. than in their dried condition, the worst being unquestionably Erith loam. Furthermore, a slight expansion was apparent. These two factors are of importance in regard to fettling costs and the freedom of castings from contraction strains and cracks.

Comparison of Results from Practice.

Table IV gives some physical properties of sand mixtures actually used in practice by progressive foundries. The most startling result is the quantity of gas evolved from the green sand shown. This sand is in use making textile castings, and it will be noticed that 1 cub. ft. of the dried green sand evolves 165.5 cub. ft. of gas. Taking into consideration the percentage of moisture required for moulding purposes, the actual gas evolved in practice will be considerably in excess of 165.5 cub. ft. This is unquestionably excessive, and the bulk of the gas evolved is due to the high content of carbonaceous matter present in the sand, such as coal dust. It was noted, however, that when the sample of this sand was heated up to 1,200 deg. C. for ½ hr. for the purpose of determining the gas evolved, no fritting or fusion of the sand took place, and the sand was extremely friable, very similar to those conditions shown by oil-sand cores. It would appear that one of the most valuable functions performed by the addi-

TABLE III.—*Suggested Requirements from Moulding Sand.*

GREEN-SAND CASTINGS (Grey Iron).

Per cent. moisture.	Green dropping test. In inches.	Permeability (secs.)	Gas evolved (cub. ft.)
5 to 7 per cent. .. .. As low as possible	As high as possible .. Not under 2.5 in. ..	As permeable as possible .. Light castings, not above 120 Medium castings, not above 100 Heavy castings, not above 80	As low as possible. Not above 100 cub. ft.

DRY-SAND CASTINGS.

Moisture content.	Green dropping test. In inches.	Dried transverse strength. Lbs. per sq. in.	Dried perm. (secs.)	Gas evolved (cub. ft.)
7 to 12 per cent. ..	2 to 3 in.	As high as possible. Not under 10 lbs. per sq. in.	As low as possible. Not above 300 secs.	As low as possible. Not above 50 cub. ft.

LOAM CASTINGS.

Moisture content.	Green dropping test. In inches.	Dried transverse strength. Lbs. per sq. in.	Dried perm. (secs.)	Gas evolved (cub. ft.)
As low as possible to obtain satisfactory permeability and freedom from drying cracks	—	As high as possible Not under 10 lbs. per sq. in.	As low as possible Not above 1,000 secs.	As low as possible. Not above 50 cub. ft.

TABLE IV.—*Actual Results from Practice.*

Type of sand.	Per cent. moisture.	Tests green. Green dropping test.	Tests green. Perm. (secs.)	Dried at 400 deg. Fah. for 1 hour. Tensile. (Lbs. per	Transverse. sq. in.)	Perm. (secs.)	Gas evolved at 1,200 deg. C.
		In.					Cub. ft.
Green sand ..	7.0	3.55	134	—	—	—	165.5
Dry sand ..	12.0	3.45	342	22	4.55	369	54.0
	18.0	3.23	9,585	87	23.40	3,933	—
Loam ..	27.47	—	—	105	10.52	1,345	49.9
Floor sand .. (see note)	12.0	3.31	335	12	2.54	412	62.3
	18.0	2.60	8,520	36	9.32	1,460	63.1
Oil sand* ..	3 per cent. binder by volume	—	—	366	59.20	46	29.0

* No. 6 Leighton Buzzard sand used with "Brunol" thin binder.

Notes on sands after being heated to 1,200 deg. C. for ½ hour—

Green sand .. No "fritting." Very friable. Slight expansion.
Dry sand .. Pronounced "fritting." Stronger than before heating. Slight expansion.
Loam .. .. Remarks as dry sand.
Oil sand .. No "fritting." Very friable. Slight expansion.

Note.—This floor sand is used as a constituent of the dry-sand mix shown above. It will be noticed that a comparison between the tests conducted green, apparently shows that the floor sand is nearly as good as the dry sand. However, the tests conducted after drying show that the floor sand is infinitely inferior. Tests conducted in the green state are of little value for controlling dry- and loam-sand mixtures.

tion of coal dust to green-sand mixtures is to allow of ready collapse of the sand after casting and the production of good finish by the total prevention of "burning on" of the sand to the casting. The other examples given in Table IV show the physical properties of dry-sand and loam mixtures in use for the production of heavy engineering and Diesel-engine work. Here again the gas content is high, and in excess of that evolved by the oil-sand core mixture shown at the base of Table IV. The comparison of the oil-sand core with the other sand mixtures gives one an excellent idea of the enormous factor of safety obtainable with the use of oil sand. There is no comparison in regard to strength and permeability, and the gas evolved from the oil sand is lower than that from any of the other sand mixtures. Before leaving this table, it is also interesting to note that the gas evolved from the floor sand, which, by the way, is incorporated as part of the dry-sand mixture, is entirely responsible for the high gas content of the dry sand. It has been found that the average floor sand in use evolves an excessive amount of gas, and so should be controlled accordingly. The dry sand shown is a mixture of Erith loam and floor sand.

Physical Properties of Silica Sands used in Nottingham District.

The physical properties of silica sands are becoming of importance due to the increased use of oil-sand core practices. It is not generally recognised that the efficiency of this practice essentially depends on the use of a correct sand. The important points to watch in regard to sand are fully dealt with in two Papers by the author—"Hidden Facts in Oil-Sand Practice" and "Efficiency in the Core Shop," published in the issues of THE FOUNDRY TRADE JOURNAL for December 19, 1929, and May 15, 1930, respectively, and it is not necessary to review matters here. Table V gives the percentage of clay present in those silica sands most commonly used in the Nottingham district, and at the foot of this table the variation in grain size found in Southport sea sand. The presence of clay, even in low percentages, leads to the use of more core binder to obtain a given strength. The same remark applies to the use of sands having a large per centage of fine grains. Such conditions may exist singly or together, and either exert a detrimental effect. For example, if a user of Southport sea sand has been in the habit of receiving supplies of this material conforming to the grain size representative of the coarser of the two samples (B) illustrated at the foot of Table V, and should by accident receive a supply, or order a supply of finer grain, as illustrated by the sand marked (A), then the quality of the cores will suffer unless more binder is added. The extra quantity of binder required will be in the nature of ½ to 1 per cent. by weight. This is increasing the cost of the oil-sand mixture to a large degree. Fig. 2 illustrates the actual volumetric percentage of clay which can occur in Southport sea sand.

TABLE V.—*Percentage of Clay in Silica Sands, and Variation in Grain Size.*

Sand.	Per cent. clay by weight. (Washing.)	Per cent. clay by volume. (Subsidence.)
Leighton Buzzard	Nil.	Nil.
Southport sea sand.. ..	Usually nil,	but varies.
Maximum core sand ..	0.56	2.40
Bromsgrove silica	1.04	1.90

Variation in Grain Size of Southport Sea Sand. Per cent. passes Mesh.

	20	30	40	60	80	90	100	120
A	99.9	99.6	99.4	93.3	55.0	43.1	17.3	11.8
B	99.8	99.6	99.2	94.7	22.7	19.4	3.9	1.0

Table VI gives the results obtained on the gas evolved from the silica sands, and also a comparison of the total gas obtainable from correctly-baked oil-sand cores.

TABLE VI.—*Gas Evolved from Sand in Oil-Sand Practice.*

Mixture.	Cores baked at 380 deg. Fah. for 1½ hours. Tensile. Lbs. per sq. in.	Transverse. Lbs. per sq. in.	Perm. (secs.)	Gas evolved.
Leighton Buzzard, No. 6— 3 per cent. "Brunol" thin (by vol.) ..	366	59.2	46	29.0
Southport sea sand— 3 per cent. "Brunol" thin (by vol.) ..	296	55.3	69	53.6
Southport sea sand— 3 per cent. raw linseed oil (by vol.) ..	312	53.1	70	58.3

1 cub. ft. of dry Leighton Buzzard sand evolves *no* gas when heated to 1,200 deg. C.

1 cub. ft. of dry Southport sea sand evolves 16 to 25 cub. ft. when heated to 1,200 deg. C.

1 cub. ft. of dry Bromsgrove silica sand evolves approx. ¾ cub. ft. gas when heated to 1,200 deg. C.

1 cub. ft. of dry maximum core sand evolves *no* gas when heated to 1,200 deg. C.

The question of blow-holes in castings cored out with oil-sand cores is an important one, and is closely linked up with the permeability and the amount of gas evolved. In many classes of castings, the use of artificial vents is not possible, and the cores are nearly totally enclosed by metal In these cases the use of the correct sand and oil binder is probably the key to successful casting production. Fig. 3 gives an excellent example of a casting, defective through blow-holes from the core.

In conclusion, are appended a few notes on the suitability of the sands tested for foundry practice.

Appendix.

Bromsgrove Red.—Useful for the manufacture of medium and light grey-iron castings, general brass-foundry and aluminium castings. The sand has a low gas content and is extensively used mixed with sea sand for oil-sand cores. The sand requires very little milling, and should not be milled excessively except for special mixtures. It is also a good blending sand for heavy castings.

Mansfield Red.—This sand is slightly finer than Bromsgrove, and is not quite as strong. It evolves considerable quantities of gas when heated.

Stourbridge Red.—The remarks given for Bromsgrove Red apply in this instance. Stourbridge Red, however, evolves more gas on casting than Bromsgrove Red.

Bramcote Red.—Used for general ironfoundry work and malleable castings. Obtainable in four grades—fine, medium, open and strong—and can be supplied both milled and unmilled.

Dale Yellow.—Obtainable from Bramcote Quarry. Suitable for brass work and for the better classes of iron castings, where a good finish is desired.

Red Sands from Warsop District, Nos. 59 and 60 Sand.—No. 59 sand is a coarse-grained sand much favoured for the heavier type of iron castings, whilst the No. 60 sand is a finer-grained sand, and used for brasswork and smaller types of iron castings where a good finish is desired.

Bromsgrove Silica.—Inland deposit of core sand. The grains are inclined to be irregular, and a percentage of clay is present. Slightly coarser in texture than Southport sea sand. Low gas evolution.

Maximum Core Sand.—This sand is from Mansfield. It is much coarser in grain size than Southport sea sand, and contains a small percentage of clay. It is, however, gas free.

Southport Sea Sand.—Used extensively as a core sand. It is inclined to vary, and the best supplies come from Birkdale. Evolves a fairly large percentage of gas.

Leighton Buzzard.—Extensively used for high-class core work. The sand is washed and graded and evolves no gas on casting. Can be obtained in various grades.

Accidents in Industry.

An interesting lecture on "The Psychology of Industrial Accidents" was given recently by Dr. G. H. Miles under the auspices of the National Institute of Industrial Psychology (of which Dr. Miles is the director) and the London Safety First Council. Dr. Miles said that whatever might be the apparent reasons, the real causes of accidents were distinctly complex. Broadly speaking, however, two distinct sets of phenomena were at work, one comprising defects in the machinery and equipment, and the other representing the human factor; of the two, the human factor was by far the more important.

Considerable attention had already been paid to mechanical equipment with a view to reducing accident risks, but there was still much more to be done in that direction. In particular, it was felt that design engineers should pay more attention to the conditions under which their machines were to be used. This would result in improvements in the ease of control, leading to a reduction in general fatigue, and in a reduction in the time taken in reacting to a dangerous situation. Consideration should also be given to the provision of more efficient personal protection in the shape of goggles, glasses, heat- and fire-proof clothing, and the provision of better guards on machines and drives to reduce the possibility of accident.

The human factors involved in industrial accidents presented a psychological problem which must be tackled along direct and indirect lines. The direct line of approach was to increase the employee's awareness of danger, particularly by the use of posters and slogans. The indirect methods of approach aimed at improving the environment under which the employees worked. Attention was paid to lighting, arrangements were made to ensure that work was carried out at the optimum temperature, between 60 and 70 deg. Fah., and steps were taken to improve the factory lay-out by the rearrangement and proper marking out of transport tracks, by covering up moving parts likely to cause visual distraction, and by taking every other practical step towards eliminating any factors likely to distract the worker's attention from his job. All this involved considerable expenditure on the part of the management. The adoption of such methods, however, definitely led to a reduction in industrial accidents, and, in consequence, in industrial losses.

Mechanisation of Industry.

Factory managements from all parts of Great Britain will consider mechanisation from the viewpoints of ownership, management and labour at a conference in London on January 16. A hundred years ago the last dramatic extension in the use of machines found both masters and men in the dark as to the probable economic consequences. As a result, dislocation, widespread suffering, serious rioting and machine-smashing occurred. To-day the new wave of mechanisation inspires both hopes and fears. On the one hand, it may show the way to lower production costs and trade recovery; on the other, it may, at least for a time, increase unemployment, and, unless watched, produce undesirable effects upon operatives involved. Consequently, there is a widespread desire to ascertain the precise value of mechanisation to British industry.

The conference, organised by a committee drawn from such bodies as the British Engineers' Association, the British Engineering Standards Association, the Industrial Welfare Society, the National Institute of Industrial Psychology, and Management Research Groups, will be addressed by Sir Horace Wilson (Chief Industrial Adviser to H.M. Government), Sir Gilbert Vyle (Past-President, Association of Chambers of Commerce), Mr. G. A. Isaacs, M.P. (General Secretary, National Society of Operative Printers), Mr. Robert R. Hyde (Director, Industrial Welfare Society), Dr. Charles S. Myers (Principal, National Institute of Industrial Psychology), Mr. Wm. Reavell (Past-President, Institution of Mechanical Engineers), Mr. W. L. Hichens, Mr. D. A. Bremner (Director, British Engineers' Association) and Mr. A. P. Young.

The Selection and Treatment of Gear Materials.*

By Francis W. Rowe, B.Sc., M.I.M.M.

The correct selection of gear materials and their treatment calls for a thorough knowledge of the stresses to which they will be subjected in service, and also a proper appreciation of the limitations imposed by manufacturing methods. The latter influence to a large extent the selection of the most suitable metal, as such factors as machinability, distortion in hardening and practicability of grinding often govern the choice.

The primary requirements of a gear are that it shall work in contact with another gear of the same or different material without undue wear, and shall carry the load without crumbling of the teeth surfaces or fracture. The question of noise also is very important, and one that needs every consideration when selecting the materials.

Resistance to Wear.

One of the chief necessities of a gear material is that it shall perform its duties without a large amount of wear taking place. Whilst a great deal of information is available on the subject of resistance to wear, there is still an enormous field for the investigator to cover. It

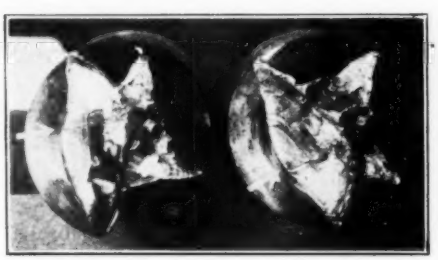


FIG. 1.—FATIGUE FAILURE OF CASE-HARDENED WORM SHAFT. FAILURE STARTED AT FLAW INDICATED BY ARROWS.

is not yet possible to state precisely by what mechanism the process of wear takes place, and engineers are only familiar with conditions conducive to rapid wear and the subsequent results.

Amongst the steels it is generally found that wear, *per se*, is more rapid in steels of low hardness, though hardness itself (as expressed by the usually applied tests such as Brinell, Rockwell, Scleroscope and Diamond hardness) is no reliable criterion as regards the capacity of the material to wear well. Other factors, as yet more or less imperfectly understood, play a large part.

In steels, the carbon content is one of great significance, it being generally found that the higher the carbon content, the greater the resistance to wear. For instance, of two carbon steels, one containing, say, 0.35 per cent. carbon, and the other, say, 0.50 per cent., treated in such a manner as to have similar physical properties, *i.e.*, Brinell hardness, tensile strength, etc., that steel with the higher carbon content will be found, in all but very exceptional circumstances, to resist wear to a greater degree. Similarly, a nickel-chrome steel with 0.30 to 0.35 per cent. carbon, 3.5 per cent. nickel and 1 per cent. chromium, heat-treated to have a tensile strength of 55 tons per sq. in., will have inferior resistance to wear to that of a 0.60 per cent. carbon steel treated to a similar tonnage. Further, a 100-ton air- or oil-hardened nickel-chrome steel has considerably less resistance to wear than a case-hardened steel (even allowing for the lesser hardness of the nickel-chrome steel) due, as far as we know, to the large difference in carbon content—0.35 per cent. as against 1 per cent.

The author does not mean, by any means, to imply that preferential selection should be made of those steels with the higher carbon content as equal consideration must in many cases be given to the questions of ductility, shock strength and other relevant factors. There is no doubt, however, that the best wearing steels are those of the highest carbon content. The highest practicable carbon content in steels for gears is about 1 per cent., and this is usually obtained by using a case-hardening steel. Direct-hardening steels of similar carbon content are seldom used, as they are less easily machined and the risk of cracking on a severe quench to secure maximum hardness is very much greater. Thus, whilst case-hardened steels are easily the best for resisting wear, other factors often preclude their use.

Resistance to Stresses other than Wear.

Whilst one of the prime considerations in a gear material is resistance to wear, other factors of equal importance have to be considered. One of the commonest causes of failure in gears is failure due to fatigue. Due to extensive researches on the subject of fatigue strength, both in this country and abroad in recent years, knowledge of fatigue phenomena has been both extended and clarified. One still, however, unfortunately meets with engineers and designers whose ideas on this important subject are vague and sometimes grossly erroneous. One still hears of fatigue being spoken of as a "crystallisation" of the metal, *i.e.*, that under the long-continued application of stress the crystals or grain size of the material grow and that failure takes place through excessive embrittlement due to the grain growth. The fallacy of this theory has been many times proved by various methods and latterly, and, it is to be hoped, finally, by the X-ray spectrograph. Stress alone can never be responsible for grain or crystal growth.

Another fallacious theory which is rather tenacious is that fatigue occurs when the stresses imposed in service exceed those of the so-called "elastic limit." This also is entirely wrong, as the "elastic limit," as revealed by the ordinary static tensile test, has no relationship with the fatigue strength of a material. This is very markedly shown in the case of copper. Annealed copper in the ordinary tensile test has practically no elastic limit. Permanent distortion takes place at very low loads. Yet this material has quite a definite and marked fatigue strength round about ± 5.5 tons per sq. in.

Of the usual physical properties determined in steels, only the tensile strength bears any relationship to the fatigue strength, and even this relationship is of a varied order. The fatigue strength of a steel under reversed bending stresses varies from 0.30 to 0.60 of the tensile strength. In the majority of cases, however, it varies from 0.4 to 0.5, so that the tensile strength does form a rough guide to this most important property.

Unfortunately, it is generally found that if the tensile strength of a material is raised by cold-working or heat-treatment, the fatigue strength is not increased in the same ratio. For example, if an annealed nickel-chromium steel has a tensile strength of, say, 45 tons per sq. in., and a fatigue strength of, say, ± 25 tons per sq. in. (0.55 of the tensile), and the tensile strength of the material is increased by heat-treatment to 100 tons per sq. in., it will be found that the fatigue strength has only increased to, say, ± 40 tons per sq. in. (0.40 of the tensile). That is, the highest ratio of fatigue strength to tensile strength is in those steels with the lowest tensile strength—the wrought irons and mild steels. However annoying and disconcerting the fact is, it is one which must be remembered and allowed for in gear design.

A failure through fatigue is usually very simple to diagnose, as the fracture in such circumstances has well-marked characteristics of its own. A fatigue failure commences by distortion and then rupture of the crystals at the point of maximum concentration of stress, which is, by the way, most usually a sharp corner, rough tool mark, or slag inclusion in the material. This small initial crack spreads more or less rapidly, dependent on the degree of overstress and the capacity of the material to resist propagation of a crack, until the section is so weakened the normal stress or some temporary abnormal stress finishes off the failure and the surface presents the characteristic appearance shown in Figs. 1 to 4. It must be remembered, however, in selecting materials to resist high fatigue stresses, that materials with extremely high fatigue limits are relatively brittle and thus have poor resistance against the shock stresses. Gears in particular are frequently subject to shock, and particular care must be taken in very many instances to incorporate material of high shock strength.

Pitting in Gears.

Another type of fatigue trouble often experienced in gears is the familiar phenomenon of

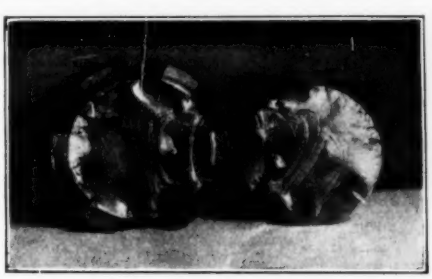


FIG. 2.—FATIGUE FAILURE OF SPLINED END OF GEAR SHAFT CAUSED THROUGH EXCESSIVE COMBINED TORSIONAL AND REVERSED BENDING STRESSES.

pitting. Pitting occurs at the point of maximum contact stress on the gear, that is, in spur and helical gears on the pitch line. Small patches of the material, varying from $\frac{1}{8}$ in. dia. and a few thousandths deep to—in extreme cases—1 in. dia., fall out of the surface of the teeth at the point of maximum stress concentration. A typical case of this character is shown in Fig. 5. The pitting is a fatigue failure resulting from excessive combined compressive and shear stresses at this point. Actually, the point of maximum concentration of stress is some way below the surface and the initial rupture takes place below the surface, spreading to the outside and causing a piece to fall out.

The remedy for such pitting usually lies in two directions. If the pitting is general over the whole face-width of the gear, it points to overstress, and the fatigue strength of the material must be raised. If, due to consideration of other necessary physical properties, this cannot be done, then the stresses must be lowered by increasing the size of the gears. If, however, the pitting is local, it points to bad contact due to inaccurate cutting or mounting, or very often excessive deflection under load. The contact between two gears may often be quite good when the gears are running under no load or a very light load, but due to lack of stiffness of the shafts or supports, the deflection under full load may restrict the contact to a very small portion of the effective face-width. Whatever may be the cause of the bad contact, it results in a small portion of the tooth carrying the whole load, and

* Extracted from a Paper read before a meeting of the Manchester Association of Engineers.

the resultant concentration of stress on to one portion results in pitting.

Cases sometimes occur also where gears and other parts fail after a time through fatigue, and it is found that substitution of a material with a higher fatigue strength results in failure occurring with greater rapidity and *still through fatigue*. A very typical example was quoted by Sir Henry Fowler regarding axle shafts in railway work. Whilst not related directly to the subject-matter of this Paper, it is given as being an instance that has been thoroughly investigated and proved.

It was found over long periods that steels with higher tensile and fatigue strength gave a shorter life than steels of lower tensile and fatigue strength for this work. In such a case it is apparent that the capacity for local deformation and thus preventing high concentrations of stress made the softer steel more valuable. If, however, the normal reversed stresses had been higher, the opposite might have proved the case; that is, a high fatigue strength might have been the more valuable property.

The capacity for plastic yielding under occasional overload of a static character is often a valuable one, as by such means a high skin stress resulting in a crack (finally developing into a fatigue failure) is often avoided.

Another particularly striking instance which came to the author's notice was that of several pairs of bevel gears for a mill drive. These gears were originally in a 0.40 per cent. carbon steel, and after two years' life were found to be pitting badly, and fatigue cracks were apparent at the roots of most of the teeth. They were replaced with case-hardened gears to provide adequate resistance to pitting and a much higher fatigue strength. The replaced gears failed in a very short time, teeth breaking off through fatigue and these being badly pitted in a localised area. Close examination showed that the housings in which these gears were fitted were bored badly out of square, with the result that the gears were in contact over a very small area of the face-width only. Yet the same conditions had been present with the weaker 0.40 per cent. carbon-steel gears, which lasted two years, as for the much stronger case-hardened gears, which lasted only a few months.

The explanation is that with the softer gears the initial bad contact, due to plasticity and low yield point in compression of the 0.40 per cent. carbon steel, had quickly spread to a reasonable contact, thus reducing the stress concentration. With the much harder material, yielding under this high-stress concentration due to localised contact was impossible, and this initial excessively high stress persisted, resulting in fatigue cracks starting at the roots of the teeth at this point, and pitting took place at this local area also. The gears were finally made right by having the gear cases rebored and fitting 55-ton nickel-chrome steel gears.

Shock Strength.

The question of resistance to shock in a gear material is often one of paramount importance. Shock strength is usually measured by means of the Izod impact test in this country. Strictly speaking, the Izod test measures the capacity of the material to resist the propagation of a crack.

There are many objections and many objectors to the Izod test on theoretical grounds, and many of these are justifiable. The fact remains, however, that the Izod test has proved of immense value to the engineering industry in general, not only as a test of quality of steel and other materials, but as a test as to its capacity for the duties it has subsequently to undergo in service.

The exigencies of manufacturing operations are such that, unfortunately, the notch effect of the Izod test-bar is reproduced in gears. Everybody is, of course, aware of the enormous stress concentration which results from such notches and wherever practicable avoid them, but the problem of eliminating everything resembling a sharp corner presents very considerable difficulties in many types of gears and gearing.

The author has encountered also several times a relationship or pseudo-relationship between Izod value and fatigue failures. In certain types of gearing, of two steels, each with the same physical properties except in regard to Izod value, the steel with a low Izod value will fail through fatigue whereas that with a high Izod value will resist the same fatigue stresses indefinitely. The author has theories on this curious relationship, but does not care to propound them without further data and research.

Fig. 3.—Fatigue Failure of Gear Tooth, probably caused by excessive Shock Stresses causing Initial Cracks at Roots of Tooth.

The facts as stated are, however, quite definite. It is the poor resistance to shock which is generally characteristic of the plain, medium and high-carbon steels in any condition of heat-treatment which precludes their use in many instances for highly-stressed gears despite their high fatigue strength and resistance to wear.

Materials Employed for Gears.

Cast Iron.

Cast iron is likely to prove a very common material for gears for a long time yet on account of its cheapness, ease of fabrication, and general applicability to various sizes of gears. Cast iron for gears should be as hard as is practicable consistent with commercial machinability. In considering all gear materials, machinability should be considered from two points of view. Material must not only be machinable but be machinable reasonably readily. Materials which present great difficulty in machining are not only undesirable from the economic point of view as regards time taken and wear of cutters, but also from accuracy point of view. Material which is very hard to machine is usually even more difficult to machine accurately, and since the great aim of gear-cutting operations is to secure greatest accuracy and a smooth surface, extremely hard material should be avoided, unless, of course, tooth profiles are to be subsequently ground.

Cast iron for gear blanks should be practically wholly pearlitic in constitution to secure good wear and tensile strength. It is advisable also to keep the phosphorus content within reasonable bounds—say, 0.6 per cent. maximum—as highly-phosphoric irons are brittle. The limitations of cast iron as regards bending stresses and shock stresses prevent its use for highly-stressed gears.

Cast Steel.

Cast steel for gear blanks should have a carbon content of 0.35 to 0.45 per cent. to give adequate resistance to wear. The castings should possess little or no trace of the marked dendritic structure representative of the "as-cast" condition, and this can only be achieved by careful normalising or annealing of an initially pure steel. With steels of high sulphur and phosphorus contents and heavy slag inclusions it is difficult to secure a good structure, and this is reflected in a poor shock strength.

Forged Mild Steel.

Mild steel with from 0.10 to 0.25 per cent. carbon is an unsuitable material for any class of gear. This remark does not, of course, embrace that grade of mild steel used for case-hardening. The author's firm abandoned some years ago the use of mild steel for gears. Its low hardness and fatigue strength, and the difficulty of securing a smooth surface free from "tears" with many types of gear-cutting methods render it a much less desirable material than a 0.35 to 0.40 per cent. plain carbon steel.

The extra cost of the higher-carbon steel over a good-quality mild steel is amply justified by the increased resistance to wear and higher-tensile and fatigue strength. It has also the advantage of machining more sweetly in gear-planing processes, such as the Sunderland or Fellowes methods. Such a steel finds a good deal of application in both the normalised and heat-treated conditions. Large turbine gear-wheel rims are made of this material and have given very excellent service.

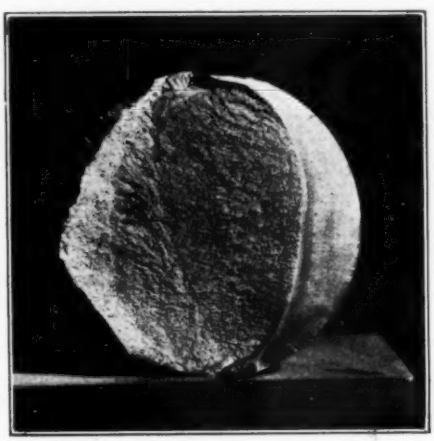


Fig. 4.—Fatigue Failure of Shaft in 45 per cent. Carbon Steel. After Fatigue Crack had spread so far, the Shaft finally failed through large Shock Blow.

0.45 to 0.55 per cent. Carbon Steel.

Steels of this character are used to a fairly large extent where the surface stresses are higher and, of course, possess a greater resistance to wear than the previous class. The chief objection to their extended use is that the shock strength is extremely variable and practically uncontrollable. The Izod impact value of a 0.50 per cent. carbon steel may vary from 2 to 30 ft.-lbs. in steels of very similar analysis and structure. It is often found also that if carbon steel of this type has a low-impact value no heat-treatment can appreciably raise it.

Another disadvantageous feature in these steels is that in large masses they are not amenable to heat-treatment unless this is of an extremely drastic character. Extremely drastic quenching is always an undesirable procedure in any large mass, due to the danger of setting up high-internal stresses which may cause internal cracks or may not be entirely relieved by subsequent tempering.

It is generally a matter of considerable difficulty to obtain a small grain size with the attendant improvement in physical properties in steel of this character. It is not, therefore, recommended for very highly-stressed parts.

Shorter Process.—Steels of this type are largely used for surface hardening by means of the oxy-acetylene flame. Probably the best method of accomplishing this is by means of the Shorter Process, where a specially-designed tank and machine do this as nearly as possible independent of manual skill. The oxy-acetylene flame traverses the face of the tooth and hardens the working faces of the tooth only. The width of the hardened band can be varied to suit the particular size of gear or the particular duties and the depth of hardening can be similarly controlled. This flame-hardening process is very useful for gears where the size is such that grinding after case-hardening or other hardening is impracticable and where the distortion is to be kept to the minimum. Since the gear is only heated very locally, practically no distortion occurs.

Plain carbon steels of higher-carbon content than this are definitely not to be recommended for gear work, on account of their greater brittleness and the impracticability of commercial heat-treatment in complicated shapes. The wealth of material at the disposal of the gearing engineer to-day is such as to render unnecessary the use of a plain carbon steel of higher-carbon content than 0.55 per cent.

Fig. 5.—Typical Pitting on Gear Tooth due to too high Stresses.

Nickel and Nickel-Chromium Steel.

Where higher stresses are to be met with than those which the plain carbon steels mentioned above can safely carry, recourse must be made to the nickel and nickel-chromium steels of tensile strengths from 45 to 65 tons per sq. in. It will be observed that such materials have no higher tensile strength than can be obtained in the plain carbon steels of medium and medium high-carbon content in small sections, but their physical properties in other directions, notably ductility and shock strength, are considerably better, and furthermore, particularly in the case of nickel-chromium steels, the physical properties can be obtained almost equally well in large as in small sections.

The straight nickel steels with from 3 to 3.5 per cent. nickel and 0.30 to 0.35 per cent. carbon are being used in diminished quantities for gears nowadays. This class of steel is a very reliable one, but the improvements which have taken place in the nickel-chromium steels in the last ten years or so have rendered them nearly as reliable as the nickel steels, and with the decided advantage of higher tensile strength and higher fatigue limits.

Probably one of the greatest factors in improving the reliability of nickel-chromium steels has been the introduction of a small amount of molybdenum varying from 0.20 to 0.70 per cent. This practice, initiated for armour-plate work, results in a steel immune from that disturbing phenomenon of temper brittleness, and gives a steel of higher impact value and one more foolproof in heat-treating.

Steels of this character may be divided into two classes: the first being the 0.30 carbon 3.5 per cent. nickel, and 0.90 per cent. chromium with from 0.20 to 0.35 per cent. molybdenum, and those with 2.5 to 2.9 per cent. nickel and 0.6 to 0.7 per cent. molybdenum. In the resultant physical properties and service performance there is very little to choose between the two classes, but the higher molybdenum steel is somewhat sluggish in responding to heat-treatment; that is, longer soaking is necessary to effect full re-crystallisation prior to quenching, and longer soaking on tempering to effect the necessary changes. The higher molybdenum steel has also a decided "knee" in the tempering curve which renders close control of the tempering temperature highly important.

These steels are generally heat-treated—oil-hardened from 840 deg. C. and tempered from 620 to 650 deg. C.—to give a tonnage from 55 to 60 tons per sq. in. In this condition they are fairly readily machinable and thus all final operations are done after heat-treatment, rendering a very highly accurate gear possible.

100-Ton Air-Hardening and Oil-Hardening Nickel-Chromium Steels.

Where higher stresses still are to be met in gears of small or medium size, gears are often made in what are popularly known as the 100-ton steels.

The bulk of the work of this character is nowadays made in air-hardening nickel-chromium steels of 0.35 per cent. carbon, 4 per cent. nickel, 1.3 per cent. chromium, and the 3.5 per cent. nickel-chrome mentioned in the previous paragraph, hardened and tempered at a low temperature—200 deg. C. The air-hardening nickel-chromium steel possesses the advantages of greater freedom from cracking due to the less severe quench (the material is, of course, hardened by heating to 850 deg. C. and cooling in air) and less distortion owing to the same cause. It is, however, more expensive in first cost and more difficult to machine than the ordinary 3.5 per cent. nickel-chromium steel.

Carefully made and heat-treated, there is little to choose from the point of view of physical properties between the two steels, although, if anything, some of the air-hardening nickel-chrome steels with 0.30 per cent. of molybdenum made nowadays have a slight advantage in this respect. Some recent consignments of this steel made to Air Board specification 2828, tested by the author, have shown an impact value from 28 to 32 ft.-lbs. associated with a tensile strength of 114 to 118 tons per sq. in., which is truly a remarkable achievement.

Case-Hardening Steels.

The use of case-hardened steels for gears has rapidly extended in this country in the last few years. Twenty years ago case-hardening was looked upon with disfavour by most engineers, and rightly so, on account of the crudeness of the methods employed. The rise of the automobile- and aero-engine industry, with their ever-increasing necessity for lower weight per horse-power, and consequently greatly increased stresses, has been largely responsible for the progress in the art of case-hardening. Case-hardening nowadays, in those factories making the most highly-stressed parts such as ball and roller bearings, roller chains and automobile gears, is conducted on a strictly scientific basis and produces an article unsurpassed and irreplaceable for highly-stressed work.

Low-Carbon Case-Hardening Steels.

The most popular class of case-hardening steel is, no doubt, still the straight low-carbon steel of from 0.12 to 0.16 per cent. carbon, which has the dual advantage of being fairly cheap in first cost and readily machined. Its disadvantages (which render it unsuitable for automobile and other gear-box gears) are that, due to its low core strength, the case, unless very deep, may collapse under heavy stresses and also cracking and exfoliation (peeling off) of the case take place more readily than in a case-hardened alloy steel. Whatever may be the properties of the core of a low-carbon case-hardening steel, there is no doubt that the case is less tough than that of an alloy case-hardening steel.

3 to 3½ per cent. Nickel Case-Hardening Steel.

There has been a definite rise in the popularity of case-hardening nickel steels in recent years. The incorporation of from 3 to 3.5 per cent. nickel in a low-carbon case-hardening steel confers on it many advantages. Primarily the tensile strength and hardness of the core are raised some 30 per cent. without any sacrifice of the ductility and shock strength. This enables surface stresses to be run up higher with a light case without danger of the case collapsing. This, of course, is due to the much higher yield point in compression in the 3 to 3.5 per cent. nickel steel. The material also has the advantage that its heat-treatment is simpler.

Fig. 6.—Section of Gear (polished and etched) hardened by Shorter Process with Oxy-Acetylene Flame.

High-Nickel and Nickel-Chrome Case-Hardening Steel.

Where higher load-carrying capacity is required, and, consequently, higher core strength, steels of higher-alloy content are used. Those finding most use are the 5 per cent. nickel, the 3.5 per cent. nickel 0.8 per cent. chromium, and the 4 per cent. nickel 1.3 per cent. chromium. This latter steel having a core strength in small sections of 80 tons per sq. in., after oil quenching, is proving of great service and its use is extending rapidly. This high strength enables very heavy surface pressures to be successfully withstood even with a light casing.

Nitrogen-Hardening Steel.

No review of either case-hardening steels or gear steels would be complete without reference to that remarkable product of German research work—the nitrogen-hardening process. This process is one of the really outstanding metallurgical inventions of recent years—outstanding not merely on account of its commercial potentialities but because it is entirely a product of painstaking thorough research work into fundamental principles.

As all of us are aware, the most disadvantageous feature of the case-hardening process, as usually conducted, is the distortion that parts so treated inevitably undergo. Where extreme accuracy is required this necessitates grinding operations after hardening, or if grinding is impracticable, then the part must be made in a

less serviceable steel. This distortion is due to the long soaking at high temperature (900 deg. C.) during carburising—from 4 to 24 hrs. Then follows a single or double quench in oil or water to develop the best physical properties—adding to the distortion.

The striking feature of the Nitralloy steels is is that the case-hardening is conducted at a temperature of 500 deg. C. only, and no subsequent quenching is necessary. If the steel is free from strain when put in for nitriding (soaking at 500 deg. C. in an atmosphere of ammonia gas) the distortion which takes place is only a fraction of what occurs in the ordinary carburising process. The case thus produced is intensely hard (Diamond hardness of 1,150 against 850 for ordinary case-hardened steel), and, consequently, more brittle.

The process has many limitations, and because of these will never oust the ordinary case-hardening steels, but for many classes of work has decided advantages and fills a long-felt want. The disadvantageous attributes of the nitrogen-hardening process are the less tough character of the case (due to its greater hardness) and the limitation of the depth of the case obtainable—0.028 in. maximum. Since, also, to obtain full advantage of the non-distorting feature of the process, all machining is to be done before hardening, the steel must be in a machinable condition, *i.e.*, not more than 60 tons per sq. in. in the majority of cases before treating. This naturally limits the core strength to this figure.

Bronze for Gears.

Bronze is largely used for gears, particularly for spiral and worm gears, where a considerable amount of sliding friction has to be encountered, and the coefficient of friction between the two gears must necessarily be low. To obtain anything like the best results the bronze gear should mate with a hardened-steel gear, and that preferably case-hardened. Phosphor-bronze, with a tin content of from 11 to 13 per cent., and phosphorus from 0.2 to 0.5 per cent. is the most suitable material as regards analysis, but the results in service depend very largely on the mode of casting. The ordinary sand casting, whilst this has to be used for large or intricate work, possesses many disadvantages from a gear engineer's point of view. It has relatively low density due to the slow rate of solidification and also is subject to internal porosity and weakness. Chilling improves this to some extent, but easily the best results both as regards strength, soundness and resistance to wear, are obtained by centrifugal casting in steel moulds. The steel mould ensures rapid solidification and the rotation and centrifugal force results in a casting of remarkably fine grain size and highest density.

Sand-cast bronze has a low resistance to fatigue failure by pitting, an example of which is illustrated in Fig. 7. Centrifugal casting raises the resistance to fatigue by pitting by about 55 per cent.

Heat-Treatment of Steel Gears.

The large and ever-increasing use of alloy and case-hardening steels in high-grade gear work has made the heat-treatment department in any gear factory one of its most important, if not the most important, section. Accurate and costly machining operations are entirely wasted if the material does not possess adequate physical properties for the duties, and these, in many instances nowadays, can only be obtained by most careful attention to heat-treatment.

The most important factor in any heat-treating operation is accurate temperature control. Furnaces for heat-treating gears and gear materials must be capable of giving a uniform temperature throughout the chamber, the design must be such that the work is evenly heated (a rather different point) and, particularly for carburising operations, the furnace must be able to maintain any required temperature over long periods with little or no variation and preferably, of course, with little or no attention. In no type of furnace can these desiderata be better achieved than in the electric furnace. In the metallic resister type of furnace (which is suitable for temperatures up to 1,000 deg. C.), heaters may be disposed to radiate heat in any or all portions of the furnace (including the door) to meet the requirements of uniform temperature and uniform heating. Furthermore, the temperature of a furnace can be maintained—without attention—for months together if required to ± 3 deg. C. of that desired. Under the stimulus of competition from the electric furnace, the gas- and oil-fired furnaces have undoubtedly progressed enormously in the last two years, but on the three main points enumerated above these furnaces can never, by the very nature of things, surpass the electric furnace, and in the author's opinion it is somewhat doubtful whether they can reach the electric furnace standard, or, at any rate, maintain it over long periods.

The author's firm operate what is probably the largest all-electric heat-treatment plant in this country—12 furnaces having a total rating of over 800 kw., and have, so far, found the results very gratifying. In selecting furnaces for heat-treating purposes, one has, of course, to be governed to some extent by local conditions relative to the price of the various fuels and electricity, but it is very surprising in many

Fig. 7.—Typical Pitting on Tooth Face of Sand-Cast Bronze Gear.

instances how competitive electricity can be. The United States of America may be said to be the pioneers in electric-resistance furnace practice, and the price of current in that country is generally as high as it is here. Also, the price of oil fuel in the States is about half the figure in this country, and yet the majority of the fine heat-treatment plants operate electric furnaces. The capital cost of the electric furnace is higher than that of a gas- or oil-fuel furnace—probably 30 to 40 per cent. higher than a similar-sized furnace of really modern design—but the running costs very often prove cheaper and, of course, the labour costs undoubtedly are.

The author's experience, extending now over two years, is that a consistent high quality of output can be maintained with the electric furnace with much less effort and worry than from a fuel-fired furnace.

Case-Hardening.

Probably the heat-treatment operations connected with gears which differ most from everyday practice, and for which specialised methods have been evolved, are those connected with case-hardening. The requirements of a carburiser for gear work are probably more stringent than for any other class. It is highly important that the edges and corners of a gear should not be over-carburised, *i.e.*, the carbon concentration must not be above 1 per cent., otherwise the gear may prove, even with the best heat-treatment, too brittle in these portions in service. This calls for a most careful formulating of the carburising compound to give the maximum rate of penetration, and a carbon content in the case of not less than 0.85 per cent. and not more than 1 per cent.

The carburising temperature must not exceed 920 deg. C. for a light case and 890 deg. C. for a deep case, and fluctuations in furnace temperature must be avoided. Over carburised or highly-cementitic cases can be caused through temperature fluctuation just as much as by high temperatures or unsuitable compounds. The depth of case required on gear work varies, of course, with the duties and size of teeth. A good general average for light and medium teeth is a case depth 15 per cent. of the thickness at the pitch line, but this may be reduced for high-core-strength steels or increased to as much as 25 per cent. for special work, such as tramway and traction gears, where exceptionally long-wearing properties are required.

The treatment subsequent to carburising depends very largely on the steel and the depth of case and the duties involved. Wherever possible a double quench should be used. The first high-temperature (900 to 920 deg. C.) quench is with the object of fully refining the core (where grain growth has taken place, due to long soaking at the carburising temperature) and breaking up any cementitic network.

Where the case is light, 0.040 in. and under, and the carburising has been conducted at 860 to 880 deg. C., and the steel contains over 3.3 per cent. nickel, the single quench at 780 deg. C. is sufficient to develop the maximum physical properties. Thus, the core is refined and fully hardened and the case also.

Where the high nickel-chrome steels are used for case-hardening, care must be exercised in carburising, as these steels are very prone to develop a highly-cementitic case on the corners and edges. For many gear parts made in carburised steel, jigs and quenching presses are used to reduce the distortion to a minimum, particularly for those parts where grinding is not possible or not practicable. Another point which is not generally appreciated in case-hardened work is that a rough surface will not, on the final quench, harden to such a high degree of hardness as a smooth one. Where the highest possible degree of hardness is required this is often an important point.

Where forgings and other parts are heat-treated prior to machining, as in the case of the carbon and alloy steels brought up to strengths varying from 40 to 60 tons per sq. in., it is very important for gear work that the heat-treatment be absolutely uniform. This is important, not only from a strength point of view, but to ensure accurate and smooth machining. For this reason, also, it is often highly desirable where a particularly good finish is required to perform a preliminary heat-treatment operation, purely to put the steel into the best possible condition for smooth and even machining.

Examination.

Apart from the foregoing details regarding selection and treatment, there also remains the questions of examination of material for general soundness. Analyses and physical tests alone are no criterion of the suitability of material for gear manufacture. Probably for no class of engineering is more stringent inspection needed. In all steels and forgings used great care is required to see that the material is free from such defects as residual pipe, centre weakness, ingot-corner weakness, heavy-slag inclusions and segregates of any description.

These involve additional tests, one of the most useful of which is the special method of hot-acid etching of sectioned bars, billets and forgings. This method very often reveals defects rendering the steel quite unsuitable for gear manufacture, whereas the usual routine tests have failed to reveal any abnormality or weakness. It should be appreciated that an accurately-cut gear is a relatively expensive article, particularly if made in an alloy steel and case-hardened and ground, and the final cost of the gear is between six and ten times the value of

(*Concluded on page* 432.)

Structural Changes during Annealing of Mild Steel.

A recent issue of the "Archiv für das Eisenhüttenwesen" contains a Paper on this subject by MESSRS. W. HEIKE and W. BRENSCHEIDT, the results of whose experiments are summarised as follow:—

When mild steel is subjected to prolonged annealing in oxidising gases, crystallites of conical or columnar form and of varying size appear in the outer portion, if stresses and carbon are present. For the production of the largest crystallites the requisite stresses correspond to a deformation of 3 per cent. in the sample. With a deformation of 6 per cent. the formation of these crystallites ceases.

When the carbon has been expelled from the core, the grain grows in that portion also; but the growth is then uniform in all directions. In this case, too, the largest grain is produced when the degree of deformation in the sample is 3 per cent.

The growth of such crystallites can be utilised in determining the stresses in the steel, and is generally equivalent to Fry's etching process.

The formation of the largest re-crystallisation grain results in a diminution of the carbon content in the sample, even when it is annealed in the lead bath. The loss is about 40 per cent.

A quite exceptionally large grain results from prolonged oxidising annealing at specific temperatures close under A_3 when the deformations in the material exceed 30 per cent. This grain growth starts from parts rich in phosphorus. With the same degrees of deformation the growth can also be obtained on prolonged annealing in the lead bath without oxidation, but the growth will be much slighter.

In annealing between A_1 and A_3 the carbon is expelled from the high-phosphorus portions and then, after several hours' annealing, grain growth occurs owing to diffusion of the phosphorus. In slightly-deformed samples the phenomenon is restricted to the narrowly-defined portions where the amount of phosphorus is highest. In samples deformed beyond the incipient value the entire core is affected. In this case the carbon is expelled from the core and hence into the outer edges of the sample, more or less completely according to the duration of annealing (annealing without oxidisation, in the lead bath).

The ferrite spots are poor in phosphorus, this being the very reason of their appearance. They owe their production to the fact that at temperatures below A_3 the mixed crystal which contains carbon liberates only low-phosphorus ferrite.

B.S. Specification for "High-Carbon" Steel Cylinders for the Storage and Transport of "Permanent" Gases.—The British Engineering Standards Association have issued a Specification for high-carbon steel cylinders for the storage and transport of "permanent gases." The Specification is based on the recommendations in the First Report of the Gas Cylinders Research Committee of the Department of Scientific and Industrial Research, for ordinary commercial cylinders for the transport of so-called "permanent gases," and is for high-carbon steel cylinders for the storage and transport of atmospheric air, oxygen, nitrogen, hydrogen, etc., which, at the usual temperature and the maximum working pressure of 120 atmospheres, remain in a gaseous state in the cylinder. The specification includes particulars of tensile, impact, flattening and hydraulic stretch and pressure tests, together with a formula for the determination of the minimum thickness of cylinder walls. It is the first published of three specifications in course of preparation by the Gas Cylinders Committee of the Association for such cylinders. Copies of the Specification (No. 399-1930) can be obtained from the British Engineering Standards Association, Publications Department, 28, Victoria Street, London, S.W.1. Price 2s. 2d. post free.

Metal Stocks in Britain.

FROM A CORRESPONDENT.

It seems hardly possible to believe that less than five years ago stocks of rough copper in this country stood at a round 50,000 tons, while at the end of November last the comparative figure was less than 2,500 tons. While the 1926 tonnage may have been rather excessive, our reserves to-day are quite inadequate, more especially if it be remembered that lately the weekly turnover on the warrant market has amounted to 10,000 tons. This means that the total on hand has been turned over four times in one week! Rather an extraordinary state of affairs, but, perhaps, a symptom of the upside-down condition of things in the world of copper generally.

As a small set-off against the big decline in stocks of rough, it may be noted that the tonnage of refined copper has lately shown an inclination to increase, the comparative figures for October and November being 4,502 tons and 5,635 tons. With the total amount of rough copper in the country sold many times over, it will be rather strange if some people do not find themselves called upon to "deliver the goods," in which event it would not be surprising to see refined copper tendered in lieu of rough, the buyer paying the usual 60s. premium. With such a depleted reserve of copper as basis for Metal Exchange operations, anyone Bearing the market runs a grave risk of being caught, and until our stocks of standard can be built up again the warrant market must continue to be rather a dangerous hunting ground. Yet another trouble arising from low stocks is price distortion, for with a "local" famine in rough copper it is obvious that prices quoted must themselves from time to time be "local," too, and not bearing a proper relation to the value put on electro.

Spelter and Lead.

Stocks of spelter were close on 13,000 tons at the end of October, but November saw some inroads made on these reserves, and by the end of that month they had come down to 12,043 tons, a very ample supply if one considers the present rate of use and the regular arrival of both high-grade and common qualities from abroad. When trade is brisk there is usually a good deal of hedging against ore purchases on the London spelter market, and for that reason a decent reserve in the country is necessary, but at the present time, when the turnover week by week does not often exceed 2,000 tons, our present stock is more than adequate.

Stocks of lead are quite an interesting study, for they seem to be steadily growing, the end of November total at 7,187 exceeding the previous month by more than 1,000 tons. Adequate control of the London market by the Lead Pool makes it necessary that metal should not be pressed for sale if the price level is to be maintained, and to that end lead has been put into warehouse rather than it should be offered to the detriment of the quotation.

The Tin Position.

The stocks of tin in the United Kingdom bulk rather largely in the world's visible supplies, and their extent and any fluctuation in their compass are, therefore, of more than passing interest. At the end of October the figure was 23,791 tons, most of which was lying at Liverpool, and the market was beginning to wonder whether any of this accumulation was ever going to be moved. Last month, however, saw some inroads made on this huge reserve, and quite a quantity was shipped to the States, the net result being a reduction to 22,354 tons at November 30. In spite of this cutting down of English stocks, visible supplies showed an increase of 1,200 tons, which looks as if Eastern stocks are being supplemented if ours are being drawn upon.

Combined Power-Generating and Heating Units.

Where there is a demand for both electric power and process or heating steam, an economical arrangement is to install electrical generating plant, driven by reasonably high-pressure non-condensing engines or turbines, and making use of the large volume of low-pressure steam thus made available.

Comparing this method with separate heating and buying electricity from an outside supply, the cost of the power generated is considerably lower. The additional heat required to raise steam at the higher pressure is so small as to be negligible, and the heat absorbed in the engine or turbine in producing its power is only about 5 per cent. of the total contained by the steam which leaves the boilers, so that the greater coal consumer—the heating system—remains whether electricity is generated on the spot or obtained from another source. Industrial establishments thus can be readily heated by exhaust steam from the engines instead of discharging to the air or throwing the steam away in condensers, where about 60 per cent. of the heat in the coal is lost in the cooling water, 450 to 500 tons of which being required for every ton of coal burnt in the boilers. Further, the thermal efficiency of a condensing unit is only about 14 to 18 per cent. from the raw coal to the switchboard, whereas with a combined power and heating plant the efficiency is at least 50 per cent. under average conditions because the exhaust steam does useful work.

Typical of modern practice in this field is the power-generation plant at the "Sentinel" Waggon Company's works at Shrewsbury. This installation comprises two "Belliss & Morcom" back-pressure engines, each of 200 kw. capacity. These engines exhaust to a heating system designed and erected by Hopes Heating & Lighting, Limited, Birmingham, which comprises 34,000 ft. of cast-iron piping for the distribution of the steam to 118 radiators, the total floor area amounting to 181,000 sq. ft. The exhaust steam from each engine is taken to a collecting header, from which it passes through an oil separator to the heating main, while a live-steam make-up is provided through a 3-in. by 6-in. reducing valve, entering the low-pressure main after the oil separator. Approximately 10,000 lbs. of exhaust steam per hour are used in normal practice at the "Sentinel" works, the pressure at the engine-exhaust branch being 3 lbs. per sq. in.

We might add that Belliss & Morcom, Limited, of Birmingham, have specialised for over thirty years on back-pressure, as well as pass-out engines and turbines, there being more than 1,450 of their installations at work throughout the world.

Russian Manganese Dumped in America.—Mr. Henry D. Baker, formerly U.S. commercial attaché in Russia, stated, through the American Manganese Producers' Association, that the Soviet government can make a paper profit of $45.62 a ton on manganese selling in the United States for $12.50. The Association now has an action pending at Washington for an anti-dumping order against Russian manganese. According to Mr. Baker, the manganese selling at $12.50 a ton on the official rate of about 2 roubles to the dollar, represents 25 roubles. These 25 roubles are evidenced by bills of exchange for United States currency. This means that 3 roubles may be issued by the State Bank of issue for every rouble represented in the shipments. Thus three times 25 roubles make 75 roubles. And then, as the Commissariat for Finance can put out treasury notes up to three-fourths of the bank notes, then three-fourths of 75 roubles or 56.25 roubles thus added to 75 roubles makes 131.25 roubles. And then converting these roubles back to dollars in the same ratio, two to one, gives $65.62. And then deducting $20 of assumed production cost, there would be a profit of $45.62 per ton.—"Steel."

Book Reviews.

Malleable Cast Iron (Der Temperguss).—A Work of Reference for the Practical Man and Student, by Dr. Ing. E. Schüz and Dr. Ing. R. Stotz. Published by Verlag Julius Springer, 23 and 24, Linkstrasse, Berlin. Price 39 marks.

Dedicated to Prof. Wüst on the occasion of his 70th birthday, this book covers the whole field of malleable cast iron, from both the practical and theoretical aspects.

First of all the history of the industry is traced, covering France, England, Belgium, the United States and other countries. It will be remembered that Deprez presented a Paper on the history of Belgian industry at the recent Liége Conference, and this section has been extracted in an appendix, thus bringing it well up to date.

The history of the melting processes—crucible, cupola, Siemens, baby-Bessemer, oil- and coal-fired furnaces—is then rapidly passed in review, terminating with the German statistics for 1929. These showed that production was carried out in 151 foundries, which made (1928) 76,480 tons (metric) or 2.43 per cent. of the total castings output. The output was shared in percentage proportions by the following melting processes:—Cupola, 75; Siemens, 16; Brackelsberg, 3.5; crucible, 2; oil furnaces, 1.5; baby-Bessemer and electric, 1 each.

Chapter II is devoted to underlying principles, and takes in the iron-carbon equilibrium diagram and a series of excellent micrographs germane to the subject. These are set out on a loose sheet carried in an envelope in the binding of the book. Fractures are similarly dealt with. Obviously the theory of annealing is included, and in this connection we are rather surprised that, whilst even minor contributions to British discussions and those printed in this journal are referred to, Gardom's work has been overlooked. "Picture-frame" and other defects are thoroughly and intelligently discussed.

Chapter III deals with the raw materials for melting and details the composition of German, British and Swedish pig-irons. Of the British, such well-known brands as Millom, Cleator, H.C.M. and Distington are listed. Table IV gives the compositional range for a number of typical castings. Then comes detailed information of the running of crucible furnaces, which apparently gives a ton of good iron ready for pouring at a cost of 247.87 marks, say, £12 7s. 10d. Cupola practice is next surveyed, and in it materials handling is considered. This process gives iron costing 123.05 marks in the ladle, say, £6 3s. per metric ton. The information about air furnaces, not being very common in German practice, is largely drawn from American sources, and actually more space is devoted to oil-fired furnaces, which apparently bring the melting cost up to 210.73 marks, or £10 10s. 9d. per metric ton, but this is without regenerators—a feature described and illustrated later. The last type of melting plant to be described is the Brackelsberg, and its cost is shown as being 123.11 marks or ½d. a ton dearer than the cupola, whilst the Siemens is calculated out at 180.32 marks or, say, £9 0s. 4d. per metric ton. After these considerations the subject of costs gets a little obscure, as duplexing and triplexing are dealt with.

The next section—sand plant and other foundry equipment—would not be very interesting if it was an English book, because there is a good deal of catalogue-illustrations and references to makers included, but, being foreign, it is interesting to see the type of plant they normally employ. Passing on to page 224, there is some matter of profound interest—the correct construction of patterns—and it includes a number of those excellent "Falsch" and "Richtig" diagrams (familiar to every visitor to a German foundry exhibition). The sections on sand blasting and grinding call for the same criticism as sand-preparing plant.

When dealing with annealing pots, the authors recommend the following composition:—C 2.6 to 2.8, Si 0.6 to 1.20, Mn 0.4 to 0.6, S 0.12 to 0.15 and P 0.1 to 0.15 per cent. Their life, we are told, is about 8 to 12 heats if the boxes are subjected to full heat for four days each time. A cast-iron alloy, containing 24 per cent. of chromium, is said to last 100 heats. A good deal of interesting information is disclosed in the section dealing with the packing media. About 25 pages are devoted to annealing ovens, and practically every type is described and clearly illustrated, whilst another six pages discusses annealing cycles, the shortest graphed being five days.

Some interesting figures are disclosed on page 305, wherein it is stated that the over-all cost of annealing is for white-heart iron £5 19s. 4d., using an old-fashioned oven, and £4 1s. 6d. using a modern tunnel furnace. Black-heart, similarly treated, costs £2 16s. 3d. and £1 16s. 9d. respectively.

The next section outlines the tests, specifications and other features associated with the commercial inspection and acceptation of malleable iron. This includes a number of illuminating curves, wherein the tensile strength is plotted against the elongation, and on these the Brackelsberg easily makes the best showing for regularity over cupola, crucible and other processes. Sandwiched in this section is one dealing with the influence of elements on various properties—a rather curious arrangement, to our mind—as immediately afterwards the authors deal with foreign specifications.

The last section—the lay-out of malleable iron foundries—gives three diagrams, and in each case we think that a little more room ought to have been given to the coremaking department. In Table 53, we notice that 41 per cent. of the total floor space is given over to moulding and casting and 6 per cent. to coremaking. However, the fact that such details are given does help to place matters in their proper perspective. In this chapter, too, costing is dealt with—a feature well understood in Germany by the majority of founders. Several useful appendices are given, including a bibliography of the subject. We can thoroughly recommend this book even to those who, like ourselves, have only a limited knowledge of German, as being the most comprehensive digest of malleable iron-foundry practice so far made available.

V. C. F.

Metallurgy of White Metal Scrap and Residues, by E. D. Thews. Published by Messrs. Chapman & Hall, Limited, 11, Henrietta Street, Covent Garden, London, W.C.2. Price 25s.

The recovery of metal from residues is becoming more important as the consumption of metals increases and the necessity of conserving world supplies becomes apparent. In consequence, there is growing up an extensive industry which is putting on the market large tonnages of secondary metals. Unfortunately, users are often prejudiced against these products on account of misguided efforts to maintain deep secrecy in regard to scrap recovery. It is easier for the proverbial camel to pass through the eye of a needle than for a visitor to inspect a scrap-smelter's works. It will be apparent, however, to those who have seen other industries benefit, as they have emerged from secrecy to a free interchange of experiences, that the scrap industry will lose nothing by Mr. Thews' exposure of its triumphs and difficulties.

It appears that Mr. Thews has had a close practical experience of his subject, and he writes throughout the main portions of his book in a manner unclouded by theory and speculation. Unfortunately, there are some sections which appear irrelevant and of less practical value than the rest. For instance, the whole of Chapters 2 to 8, describing white metals, type metals, solders, pewters, Britannia metal, fusible alloys and shot, which contain copious lists of alloys, descriptions of type-setting machinery, dissertations on the theory of bearing metals and other details more appropriate to other specialised works, appear to have little relation to scrap recovery, and would have made the book less diffuse by their omission.

The essence of the book is contained in Chapters 1, 9 to 11, 14 to 16, 22 and 23, which deal with smelting and refining of tin, white metal, lead, zinc and aluminium scrap, slags and residues and the recovery of flue dust and fume. In these pages the practical smelter will find a mine of valuable and critical information strictly pertinent to his business. Details of processes and ample instructions for their operation are fully described.

The plant required by the scrap smelter is described, where appropriate, in the accounts of processes, and is dealt with separately in Chapters 12, 13, 17 to 21 and 24. These chapters discuss lead blast furnaces, blast-furnace coke, reverberatory furnaces, refractories, crucibles, melting pots and chimneys.

A chapter on sampling, after exposing with diverting frankness some of the tricks of the trade, gives practical instructions for honestly sampling a long range of scrap-metal products, and it is wisely stressed throughout how much care, skill and knowledge is necessary in this work.

There are also included some German and American specifications, a few ordinary tables and an adequate index. The book is well printed, but (for its price) not too well bound. It contains 383 pages and 70 illustrations.

The work is written essentially from the standard of American practice, constantly contrasted with German methods. One might wonder whether the slight reference to British practice is due to the author's lack of experience in this country or to our backwardness in scrap-metal recovery. In the latter event the book should be especially useful to British readers.

H. C. D.

Die Grundlagen des Walzens, by Ernst Cotel. Published by Wilhelm Knapp, Halle (Saale), Germany. Price, in paper covers, 6.60 Rmks.; bound, 7.90 Rmks.

The bulk of this little treatise on the Fundamental Principles of Rolling is intended for the rolling-mill engineer and roll designer. The only portion that will interest the foundryman is Chapter III, and a very small portion of that, as most of it is elementary material, and much of it is again of interest to the rolling-mill engineer only, dealing as it does with the storing and maintenance of mill-rolls.

The Selection and Treatment of Gear Materials.

(*Concluded from page* 430.)

the material. Such being the case, any extra care expended on making certain the material is perfectly sound before commencing manufacture is amply repaid in avoiding rejections at a late stage in machining, or replacements due to service failures.

In conclusion, the author would like to point out that in a review of so vast a subject as is covered by this Paper, generalised statements, which may not be true in exceptional cases, can hardly be avoided. He has endeavoured also to avoid metallurgical technicalities, as far as possible, to make the subject readily understandable to those without specialised knowledge in metallurgy. He also desires to express his warmest thanks to the directors of David Brown & Sons (Huddersfield), Limited, the gear specialists, for their permission to publish this Paper, the major portion of the data for which has been accumulated from their service experiences and in their research laboratories.

Trade Talk.

SIX MEN were burned about the hands and feet at the Bow Foundry, London, E., on Monday, when molten metal was being poured into a mould.

MESSRS. W. BREALEY & COMPANY, LIMITED, have removed from Prospect Works, Hawksley Avenue, Hillsborough, to Station Works, Ecclesfield, Sheffield.

ACCORDING TO THE German Labour Department's computations, the number of unemployed in Germany increased between November 15 and November 30 by 204,000 to 3,762,000.

THE DARLINGTON FORGE, LIMITED, have received a substantial order for steel castings and forgings to be fitted in the new Cunard liner which is to be built by Messrs. John Brown & Company, Limited, at Clydebank.

MESSRS. ROBERT THOMPSON & SONS, LIMITED, Sunderland, have received from Continental owners an order for two motor tankers. The firm's shipyard, which had been without work for some months, will now be reopened.

THE HARDY PATENT PICK COMPANY, LIMITED, of the Mining Tool and Mining Engineering Works, Sheffield, announce that the name of the company has now been altered to Messrs. Hardypick, Limited. The telegraphic and cable address and telephone numbers are unchanged.

THE BOARD OF DIRECTORS of the South African Iron & Steel Industrial Corporation have approved the acceptance of all tenders for the construction of the South African State steelworks, particulars of which were announced in our issue of November 20. Work is to be started immediately.

TWO MEN, W. Oxley and J. Young, were killed at the Cochrane Ironworks at Middlesbrough on Monday whilst working in a pipe pit. Mould boxes above the pit were overturned and red-hot pipes rolled down upon the men, who were crushed and terribly injured. Their comrades displayed great courage in extricating the men from the red-hot *débris*.

DEBENTURE HOLDERS OF Messrs. Fairbairn, Lawson, Combe, Barbour, Limited, textile and general engineers, are being asked to sanction the creation and issue of a prior lien debenture for £200,000 to the company's bankers as security for any advances up to that amount. The directors state that fresh capital is essential if the business is to be placed on a profit-earning basis.

THE ALLGEMEINE ELEKTRIZITÄTS-GESELLSCHAFT ("A.E.G.") and the Borsig Lokomotivwerke have decided to combine. Up till now the Borsig, which is one of the oldest established locomotive works in Germany, has held aloof from fusion. In some quarters it is stated that the A.E.G. contemplates a further fusion with the well-known locomotive works of L. Schwartzkopff, of Berlin, which at present stands third on the Federal State Railway Company's quota list.

MESSRS. COX & DANKS, LIMITED, who are engaged on the salvage of the scuttled ex-German fleet at Scapa Flow, were successful last week in raising the 20,000-ton ex-German battle cruiser "Von der Tann," which had lain keel uppermost in 13 fathoms of water since she was scuttled on June 21, 1919. The total tonnage now raised by Messrs. Cox & Danks since they commenced their operations at Scapa Flow in 1924 is 150,000, which includes four battle cruisers, a battleship, a light cruiser and 25 destroyers. The firm's activities will be directed early next year on the 25,000-ton battleship, "Prinz Regent Luitpold."

TWO IMPORTANT ORDERS received by the English Electric Company, Limited, come from Scotland and South America. That for Scotland is in connection with the Lanarkshire hydro-electric scheme, and covers the conversion, from 25 cycles to 50 cycles, of the main generating units at Bonnington and Stonebyres power stations. These turbine-alternator sets, two of 7,000 h.p. at Bonnington and two of 4,000 h.p. at Stonebyres, together with the complete hydro-electric auxiliaries, were supplied by the English Electric Company. The conversion of one set at Bonnington has already been carried out. The order from South America is from the Buenos Aires Great Southern Railway. New stock for the railway will include three eight-coach trains, each train having attached to it a self-propelling Diesel-electric power house. For this stock the English Electric Company will supply 62 motors, each of 135 h.p., and control equipments. They are also supplying six motors and control equipments for a 1,700-h.p. high-speed Diesel-electric locomotive which is under construction.

THE FULL MERGER, to be retroactive as from July 1, 1930, of the two large German companies, the Hoesch Iron & Steel Works Company at Dortmund and the Köln-Neuessen Mining Union at Essen, was decided upon definitely at a combined board meeting of the two concerns at Essen recently. The Hoesch Company is to increase its capital by 71.41 million marks, which is equal to the present share capital of Köln-Neuessen, and will exchange shares in the ratio of one to one. The new company, which will have a total share capital of 142.76 million marks, will be named Hoesch-Köln-Neuessen A.-G. für Bergbau-und-Hüttenbetrieb. The combining companies, Hoesch and Köln-Neuessen, will propose at the general meeting on December 22 a dividend reduction for the financial year 1929-30 of 1 per cent. each—that is, to 6 per cent. and 6½ per cent. respectively. Both concerns, in co-operation with the Basel Trading Bank, formed a new company with a share capital of 7,000,000 Swiss francs, of which 5,000,000 fcs. are to be paid up at present, under the name of Montan Union A.-G., at Basel a short time ago, which is chiefly to finance ore-trading concerns in Norway, Sweden and Brazil, and coal-trading enterprises mostly situated in Holland and Italy. The Hoesch and Köln-Neuessen companies have already been co-operating for about ten years.

Personal.

MR. G. SCOTT RAM has retired from the position of Senior Electrical Inspector of Factories, under the Home Office. He has been succeeded by Mr. H. W. Swann.

MR. RALPH S. MACPHERRAN, chief chemist of the Allis-Chalmers Manufacturing Company, Milwaukee, U.S.A., and one of the outstanding metallurgists in the field of cast iron, has been awarded the J. H. Whiting gold medal of the American Foundrymen's Association for his valued contributions to the foundry industry. The award was unanimously voted by the American Foundrymen's Association Board of Awards recently, and has since been approved by the board of directors. The J. H. Whiting gold medal is one of four awards made by the American Foundrymen's Association for the purpose of encouraging and stimulating meritorious achievements in the foundry industry. Granting of these awards is vested in a permanent and self-perpetuating Board of Awards, consisting of the seven living Past-Presidents of the Association, the chairman being the last President. Mr. MacPherran, for many years a prominent and active contributor to the committee work of the Association and the American Society for Testing Materials, has been identified with the iron and steel industry for nearly thirty years. Born on February 1, 1871, he received a technical education at the University of Wisconsin and University of Michigan, graduating from the latter institution in 1892 with a B.S. degree in chemistry. On leaving college he was associated for three years with the Illinois Steel Company at the Joliet and South Chicago, Ill., works, and became connected with the former E. P. Allis Company, of Milwaukee, in 1895. Leaving that firm in 1907, he spent one year with the J. I. Case Threshing Machine Company, Racine, Wis., before returning to the newly-formed Allis-Chalmers Manufacturing Company, Milwaukee. Mr. MacPherran has been associated with the Allis-Chalmers organisation ever since, in charge of their chemical and physical laboratories. Mr. MacPherran is especially noted for his co-operation in the committee activities of several technical organisations and for the assistance he has given many young metallurgists in the field of cast iron. As the result of his continuous and valuable investigations of cast iron, Mr. MacPherran has contributed numerous Papers on the metallurgy of both cast iron and steel before the meetings of various technical associations, as well as to the technical Press.

Wills.

BRIGGS, JOSEPH, of Ambergate, Derby, late manager of Messrs. Richard Johnson & Nephew, Limited £5,022

NORTON-GRIFFITHS, SIR JOHN, governing director of Messrs. Norton-Griffiths & Company, Limited, engineers and public works contractors £5,392

Reports and Dividends.

International Nickel Company of Canada, Limited.—Quarterly dividend on the preferred stock of 1¾ per cent.

Petters, Limited.—Interim dividend on the 7½ per cent. cumulative preference shares for the half-year ended September 30.

Allen West & Company, Limited.—Net profit, £54,443; brought in, £61,642; depreciation reserve, £10,000; dividend of 6 per cent. on the ordinary shares, £18,000; carried forward, £75,069.

Shotts Iron Company, Limited.—Net profit, after providing £25,000 for depreciation, £3,378; brought in, £38,290; no dividend on the ordinary shares; preference dividend, £5,274; carried forward, £36,394.

Contracts Open.

Limerick, January 6.—2,000 yds. of cast-iron pipes, for the Corporation. Mr. P. F. Purcell, consulting engineer, Ashton, Killiney, County Dublin. (Fee £5, returnable.)

Little Hale, Lincs, December 23.—650 yds. of 2-in. cast-iron and 364 yds. of 1-in. wrought-iron water main, for the Sleaford Rural District Council. Mr. E. H. Sills, engineer, Council Offices, Northgate, Sleaford.

Pickering, Yorks, December 20.—4,990 yds. of spigot and socket cast-iron pipes and specials, for the Pickering Rural District Council. Mr. H. Smith, engineer, Carr House, Snainton. (Fee £2 2s., returnable.)

New Company.

George Clark & Sons (Hull), Limited, Trinity Works, Hawthorn Avenue, Hull.—Capital £100. Founders, etc. Directors: J. Wilson, F. Burrell, F. G. Burrell, R. M. Wilson and T. R. Ferens.

Hints for Commercial Visitors to Algeria, Tunisia, Tripolitania, and Cyrenaica.—A pamphlet bearing this title has been published by the Department of Overseas Trade. It has been prepared by the British Consular Officers at Algiers, Tunis, Tripoli and Bengasi respectively. Copies may be obtained from the Stationery Office, Adastral House, Kingsway, London, W.C.2.

Development of the Bridge.—At the opening meeting of the 50th Session of the Junior Institution of Engineers, Mr. S. J. Crispin, of Cornwall, gave an illustrated lecture tracing the development of bridge construction from the primitive method of bridging a stream by felling a tree across it to the gigantic structures recently placed across the Tyne and that now completing across Sydney Harbour. The first iron bridge constructed in England, probably in the world, was at Coalbrookdale, erected by Abraham Darby in 1779. Wrought iron as a bridge building material came some time after cast iron. Fairbairn first used plates and angles riveted together, which method gave great impetus to iron-bridge construction. In describing Brunel's bridge at Saltash across the Tamar, a longitudinal view of the upper surface of one of the oval arched tubes, 16 ft. 9 in. by 12 ft. 3 in., from which hang the suspension members, showed a rail fixed some 4 in. above the surface of the tube, designed to facilitate the passage of workmen across the top of the tube, the toes being placed under the rail and the man proceeding sideways; a handrail was later provided. Practically all the timber-trestle viaducts and bridges in Cornwall had now been superseded by more durable structures; at Treliever was one resting on stone piers rising up to within 35 ft. of rail level, upon which, radiating beams were placed to carry the superstructure. This bridge, like many of Brunel's, is curved, which he considered increased its stability. The suspension bridge in its various forms was illustrated by many examples, concluding with the largest structure of this type now in course of erection, the one across the Hudson River at New York. Bridges of the cantilever type comprised the Forth Bridge and the Tower Bridge. The lecture concluded with some interesting details of the construction of the Sydney Harbour Bridge, now in process of erection.

Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—The process of winding up the past year's business operations at present would seem the chief occupation of members of the Cleveland iron market, for, judging by the small attendances of late, very little interest is taken in the few transactions recorded on these occasions. The position existing at the moment may be briefly explained. In the first place, output is restricted, prices fixed, and merchants are operating with limitations as to the area of distribution, in a manner which they assert makes it difficult to negotiate business in any circumstances, and doubly so when demand is so limited. Stocks of iron have of late tended to increase, and makers are becoming anxious to negotiate contracts for the early months of next year. In the majority of cases, however, consumers show no inclination to enter into commitments so far ahead, and the bulk of the day-to-day transactions are for small quantities for early delivery. In the meantime, the export of pig-iron from the Tees is on a fluctuating scale, while the pressure of foreign competition in the home markets continues with increasing weight. There has been, however, no alteration in prices, which remain as follow:—No. 3 Cleveland G.M.B. is quoted 63s. 6d. per ton, both for home delivery and for export; No. 1 foundry iron is 66s.; No. 4 foundry iron, 62s. 6d.; and No. 4 forge iron, 62s. per ton.

In the market for East Coast hematite it is of interest to note that, while foreign competition continues intense, the home makers manage to maintain a fair volume of trade, satisfactory orders having been recently fulfilled with Italian and Danish consumers, while Sheffield is also taking regular deliveries. In some cases consumers are discussing contracts for the early months of next year, and it is noteworthy that, whilst prompt parcels of East Coast mixed numbers are obtainable at 70s. 6d. per ton, 71s. is quoted for forward deliveries. On the North-West Coast, Bessemer mixed numbers are quoted at 70s. per ton at works.

LANCASHIRE.—Considering the existing conditions of trade, it is at least satisfactory to note that there is certainly a little more animation in local markets for foundry pig, with users showing more interest in supplies. In view of the general belief that no further revision of Midland iron prices will be made before the end of January at the earliest, a fair volume of forward business has been placed up to the end of that month, but beyond that there is at present no disposition to venture. Quotations remain as follow:—Derbyshire and Staffordshire No. 3 pig-iron is quoted for delivery to local consumers at 69s. 6d. per ton, with Scotch brands unaltered at 91s. per ton delivered locally.

THE MIDLANDS.—At the Birmingham market for foundry pig, although no large tonnages are included in the present transactions, business in small lots for immediate despatch is progressive. But there is still no general disposition among the consumers to enter into forward business, as the state of their order-books does not warrant the ironfounders committing themselves very far ahead. Previous quotations apply in every direction, namely, 67s. 6d. for No. 3 Northants and 71s. for Derbyshire and North Staffordshire No. 3, delivered local stations.

SCOTLAND.—In the market for Scotch pig-iron the business being done in this area is being further curtailed. The demand for foundry pig-iron is exceedingly poor, as founders, especially in the engineering section, are short of orders. Notwithstanding this, however, the makers maintain their minimum price of 76s. 6d. for No. 3 foundry, f.o.t. furnaces.

Finished Iron.

The position affecting iron bars has not altered in any respect. Specifications for crown bars are still very hard to obtain, and no heavy tonnages are involved at the present time. There is intense competition for what business is available from consumers and stock warehouses in the Birmingham district, and the Midland makers are having to contend with keen rates from manufacturers in other directions. The local price for a good crown iron varies from £9 15s. to £10 5s., but figures under £9 15s. are being quoted from Lancashire. There is not likely to be any improvement in the demand for nut and bolt iron whilst Continental competition remains so keen. The local makers quote £8 15s., while the foreign makers' prices, delivered locally, are as low as £5 7s. 6d. to £5 12s. 6d. Marked bars continue a steady market at £12 10s per ton at works.

Steel.

In the semi-finished steel department the pressure of foreign competition is severely felt, in spite of the recent advance in the prices of Continental material. The greater part of the business transacted by British works appears to be for comparatively small orders for near delivery. On the other hand, it is understood that heavy imports of Continental semi-finished steel must be expected for some time against recent purchases. Irregular conditions still obtain in the finished-steel section of the market. The home demand has improved of late, but competition from Continental sources is keen, particularly in the overseas markets. The tinplate market is quiet, with quotations ruling for coke quality on the basis of 15s. 9d. to 16s., net cash, f.o.b. Welsh ports.

Scrap.

Markets for foundry scrap material continue on the quiet side, although a little more animation is reported on Tees-side. Prices are, however, unchanged; cast iron of ordinary quality is still at 50s., and machinery scrap, broken into convenient pieces, at 52s. 6d. per ton. Cast-iron borings are nominal at 30s. per ton. In Birmingham, heavy machinery cast iron in handy sizes for foundry work is offered at 57s. 6d. to 60s., but light cast iron is weak at 40s. 6d., both delivered works. In Scotland, machinery cast-iron scrap, suitable for foundries, is quoted at 57s. 6d., ordinary cast-iron scrap to the same specification 52s. 6d., and cast-iron railway chairs 56s. 3d. There is practically no outlet at the moment for light metal, the price of which is 40s., with furnace firebars at 2s. 6d. less. The above prices are all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—The market for warrant copper during the past week developed an irregular tendency, with prices declining to lower levels. Evidently it is not, however, the intention of the copper producers to sell at the bottom level, for the tonnage allocated to their sales agents in this country has been meagre in the extreme. For the moment there is no evidence of serious under-cutting of the exporters' quotation, and, on the other hand, outside producers are becoming wary of offering too freely.

Closing quotations :—

Cash.—Thursday, £46 1s. 3d. to £46 2s. 6d.; Friday. £45 7s. 6d. to £45 8s. 9d.; Monday, £45 7s. 6d. to £45 10s.; Tuesday, £44 5s. to £44 6s. 3d.

Three Months.—Thursday, £46 1s. 3d. to £46 2s. 6d.; Friday, £45 5s. to £45 6s. 3d.; Monday, £45 to £45 1s. 3d.; Tuesday, £44 1s. 3d. to £44 2s. 6d.

Tin.—In the market for standard tin, the approach of the holidays and stocktaking have naturally exercised a restraining influence on general business, the quietness of the tinplate trade being a contributory factor here. Towards mid-week the market suffered a serious relapse, current quotations dropping to about £105 10s. per ton, and closing with a very considerable decline on the previous week's figure.

Official closing prices :—

Cash.—Thursday, £108 17s. 6d. to £109; Friday, £108 5s. to £108 7s. 6d.; Monday, £106 12s. 6d. to £106 15s.; Tuesday, £105 10s. to £105 15s.

Three Months.—Thursday, £110 to £110 2s. 6d.; Friday, £109 5s. to £109 7s. 6d.; Monday, £107 15s. to £107 17s. 6d.; Tuesday, £106 15s. to £106 17s. 6d.

Spelter.—The market for this metal continues depressed, and during the past week nearly touched the lowest price on record. But at that point resistance has been shown, and, in spite of pessimism regarding the outlook, the fact cannot be escaped that this metal appears to be cheap. Stocks, although ample, are not excessive.

Daily fluctuations :—

Ordinary. — Thursday, £13 15s.; Friday, £13 12s. 6d.; Monday, £13 10s.; Tuesday, £13 6s. 3d.

Lead.—Apart from a slightly easier tone, there is little fresh news to report. Buying by consumers has been satisfactory during the last few days, but statistically the lead position is not very good.

The week's prices have been :—

Soft Foreign (Prompt).—Thursday, £15 8s. 9d.; Friday, £15 2s 6d.; Monday, £15 2s. 6d.; Tuesday, £14 17s 6d.

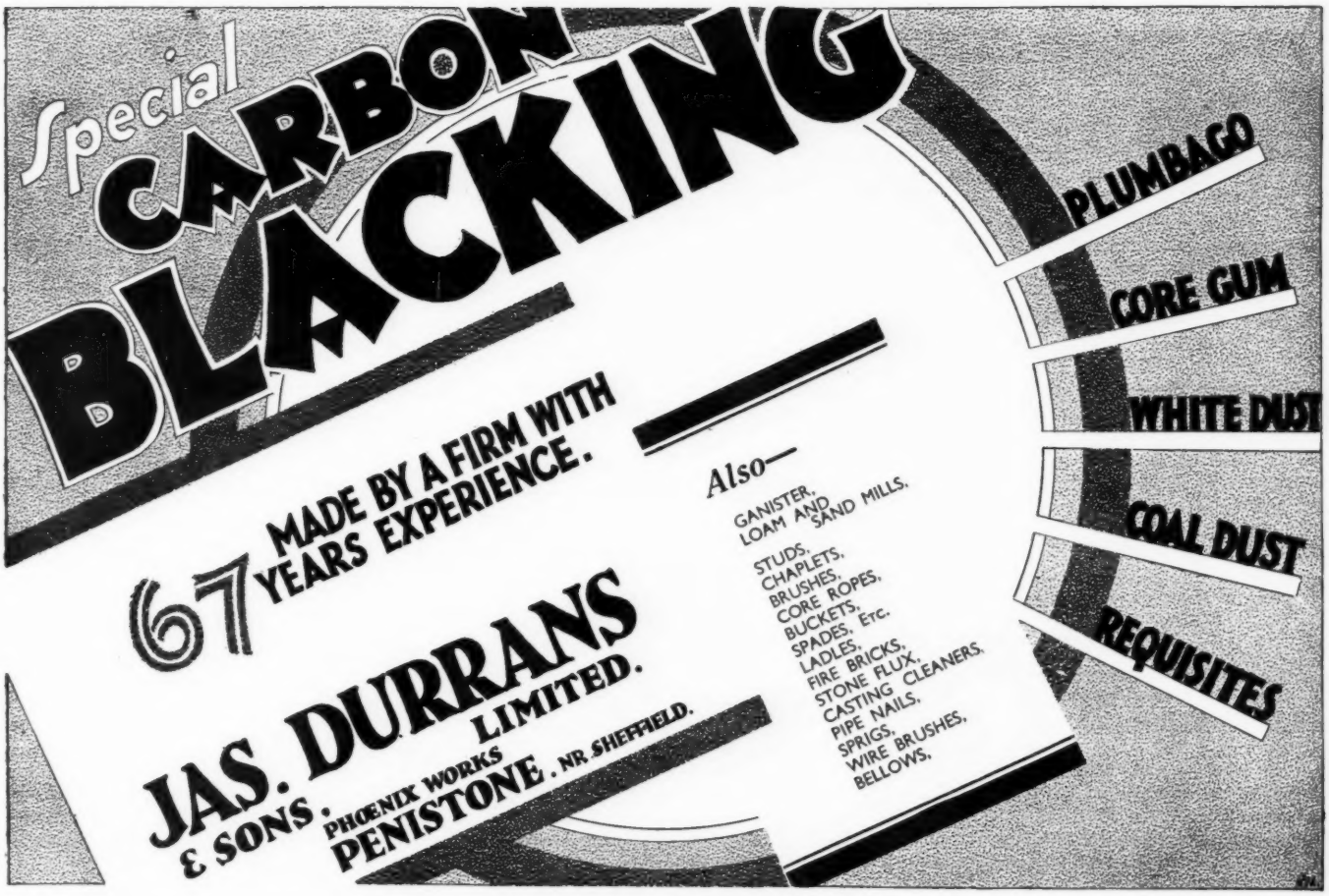
British Aluminium Company, Limited.

Subscriptions were invited on December 9 to an issue of £2,500,000 5 per cent. first mortgage debenture stock in the British Aluminium Company, Limited. The issue was made at 98½ per cent., and was over-subscribed. The company has an authorised capital of £2,400,000, half in preference and half in ordinary shares. The issued capital is £1,000,000 in preference and £1,001,034 in ordinary shares. Debenture stock of £491,909 and £745,600 prior lien debentures outstanding are to be redeemed. The prospectus stated that the company is one of the largest producers of aluminium in the world and the only large producer of the metal in the British Isles. The world's production of aluminium has increased rapidly. It is estimated that in the year 1900 it amounted to 5,000 tons per annum, in 1920 to about 150,000 tons, and in 1929 to approximately 250,000 tons per annum. The company controls extensive deposits of bauxite, and owns directly hydro-electric works for the production of aluminium at Foyers and Kinlochleven, a factory for the production of carbon electrodes at Kinlochleven, chemical factories for the refining of bauxite at Burntisland and Larne, and rolling mills at Warrington and Milton. The company also owns the entire share capital of the North British Aluminium Company, Limited, which owns and operates works for the production of aluminium at Lochaber, and of two subsidiary companies in Norway. It also controls through subsidiary companies various works at home and abroad for the fabrication of aluminium in various forms and for allied operations. The company promoted the Lochaber Water Power Act, 1921, for the purpose of developing water power in the Lochaber district of Inverness-shire. In 1924 the North British Aluminium Company, Limited, was formed for carrying out the works authorised by the Act and for the production of aluminium. The first stage of the Lochaber works has been completed and operations were commenced at the end of 1929. The hydro-electric plant in operation at Lochaber is at present about 33,000 e.h.p. The complete scheme is calculated to develop continuously up to approximately 100,000 e.h.p., and to treble the present output of aluminium from these works.

The shareholders of Messrs. James Dunlop & Company, Limited, at an extraordinary general meeting at Glasgow, approved the proposed agreement with Messrs. David Colville & Sons, Limited, which provides for the formation of a new company, to be called Colvilles, Limited, and the exchange of shares. The cancellation of preference dividend arrears was also approved. Full particulars of the agreement were published in our issue on November 27.

Record Temperature.—What is believed to be the highest temperature ever attained was demonstrated recently at the Westinghouse Research Laboratories when 900,000 deg. Fah. was recorded. The temperature was estimated by the velocity of the molecules of the electrode metal, and was generated in a nearly-perfect vacuum. It was developed in the course of an investigation into the characteristics of electric arcs in vacuum.—"The Iron Age."

XUM


Special
CARBON
BLACKING
PLUMBAGO
CORE GUM
WHITE DUST
COAL DUST
REQUISITES
67 MADE BY A FIRM WITH YEARS EXPERIENCE.
JAS. DURRANS & SONS. LIMITED.
PHŒNIX WORKS PENISTONE. NR. SHEFFIELD.
Also—
GANISTER, LOAM AND SAND MILLS.
STUDS, CHAPLETS, BRUSHES, CORE ROPES, BUCKETS, SPADES, ETC. LADLES, FIRE BRICKS, STONE FLUX, CASTING CLEANERS, PIPE NAILS, SPRIGS, WIRE BRUSHES, BELLOWS.

CAST IRON FLANGED PIPES

2 in.—12 in. & CONNECTIONS. to 24 in. dia.

WE HAVE FIFTY-TWO YEARS OF ACCUMULATED EXPERIENCE AND METAL PATTERNS.

JAMES & RONALD RITCHIE, LTD.,

Telephone: 3852 (2 Lines). MIDDLESBROUGH. Telegrams: "Ritchie, Middlesbrough."

R. B. TENNENT, LTD., COATBRIDGE, N.B.

Telegrams: "Tennent, Founders, Coatbridge." Established 1857. Telephone: No. 425-426, Coatbridge.

IRON & STEEL FOUNDERS

SPECIAL AIR FURNACE IRON. SIEMENS' STEEL ONLY.

HEAVY CASTINGS

OF ALL KINDS FOR IRON AND STEEL WORKS

Iron Castings up to 100 tons each. Steel Castings up to 40 tons each.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	44	5	0
Three months	44	1	3
Electrolytic	47	0	0
Tough	47	0	0
Best selected	47	10	0
Sheets	80	0	0
India	61	0	0
Wire bars	52	3	9
Do. February	52	3	9
Do. March	52	3	9
Ingot bars	52	3	9
H.C. wire rods	53	0	0
Off. av. cash, November	46	3	8¼
Do., 3 mths. November	46	3	10½
Do., Sttlmnt., November	46	3	1½
Do., Electro, November	49	10	3
Do., B.S., November	48	1	10½
Do., wire bars, November	50	1	3
Solid drawn tubes			11¼d.
Brazed tubes			11¼d.
Wire			8d.

BRASS.

Solid drawn tubes	10¼d.
Brazed tubes	12¼d.
Rods, drawn	9½d.
Rods, extd. or rlld.	6d.
Sheets to 10 w.g.	8¼d.
Wire	8¼d.
Rolled metal	8¼d.
Yellow metal rods	6d.
Do. 4 × 4 Squares	6¼d.
Do. 4 × 3 Sheets	6¼d.

TIN.

	£	s.	d.
Standard cash	105	10	0
Three months	106	15	0
English	106	10	0
Bars	109	15	0
Straits	109	15	0
Australian	107	0	0
Eastern	112	7	6
Banca	109	0	0
Off. av. cash, November	113	11	10½
Do., 3 mths., November	114	18	3½
Do., Sttlmt., November	113	11	3

SPELTER.

	£	s.	d.
Ordinary	13	6	3
Remelted	12	2	6
Hard	10	12	6
Electro 99.9	15	15	0
English	13	17	6
India	11	12	6
Zinc dust	20	0	0
Zinc ashes	3	0	0
Off. aver., November	14	19	5¼
Aver., spot, November	14	14	1½

LEAD.

	£	s.	d.
Soft foreign ppt.	14	17	6
English	16	5	0
Off. average, November	15	18	7½
Average spot, November	15	18	8½

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	24	0	0
Do. V.M. ex-whf.	24	0	0
Rods	27	0	0
Boiler plates	19	10	0
Battery plates	20	0	0

ANTIMONY.

	£	s.	d.
Special brand, Eng.	36	0	0
Chinese	25	5	0
Crude	22	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	22	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£7 17 6
45/50%	£11 10 0
75%	£18 10 0
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% c. free	4/2 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	11¾d. lb.
Ferro-phosphorus, 20/25%	£15 17 6
Ferro-tungsten—	
80/85%	2/3 lb.
Tungsten metal powder—	
98/99%	2/6 lb.
Ferro-chrome—	
2/4% car.	£30 10 0
4/6% car.	£23 0 0
6/8% car.	£22 10 0
8/10% car.	£22 2 6
Ferro-chrome—	
Max. 2% car.	£32 17 6
Max. 1% car.	£37 15 0
Max. 0.70% car.	£41 0 0
70% carbon-free	10d. lb.
Nickel—99% cubes, or pellets	£175 0 0
Ferro-cobalt	9/7 lb.
Aluminium 98/99%	£85 0 0
Metallic chromium—	
96/98%	2/7 lb.
Ferro-manganese (net)—	
76/80% loose	£11 0 0 to £11 10 0
76/80% packed	£12 0 0 to £12 15 0
76/80% export	£10 10 0 to £11 0 0
Metallic manganese—	
94/96% carbonless	1/4 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 2
Finished bars, 18% tungsten	£0 3 0

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{3}{16}$ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ⅛ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel				2	5	0
Bundled steel and shrngs.	1	15	0 to	1	18	0
Mixed iron and steel	1	17	6 to	2	0	0
Heavy cast iron				2	5	0
Good machinery for foundries				2	7	6
Cleveland—						
Heavy steel				2	6	0
Steel turnings				1	15	0
Cast-iron borings				1	10	0
Heavy forge				3	2	6
W.I. piling scrap				2	17	6
Cast-iron scrap	2	10	0 to	2	12	6
Midlands—						
Ord.cast-iron scrap	2	2	6 to	2	5	0
Heavy wrought	2	17	6 to	3	2	6
Steel turnings	0	17	6 to	1	0	0
Scotland—						
Heavy steel				2	7	6
Ordinary cast iron				2	12	6
Engineers' turnings				1	12	6
Cast-iron borings				1	15	0
Wrought-iron piling				3	0	0
Heavy machinery				2	17	6

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	37	0	0
Brass	29	0	0
Lead (less usual draft)	14	0	0
Tea lead	10	10	0
Zinc	8	0	0
New aluminium cuttings	50	0	0
Braziery copper	34	0	0
Gunmetal	38	0	0
Hollow pewter	80	0	0
Shaped black pewter	60	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	66/-
Foundry No. 3	63/6
Foundry No. 4	62/6
Forge No. 4	62/-
Hematite No. 1	71/-
Hematite M/Nos.	70/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	78/-
d/d Birm.	88/6
Midlands—	
Staffs. common*	—
No. 4 forge*	66/-
No. 3 fdry.*	71/-
Shrops. basic	—
Cold blast, ord.	—
roll iron	—
Northants forge*	62/6
fdry. No. 3*	67/6
Derbyshire forge*	66/-
fdry. No. 3*	71/-
basic*	—
*d/d Black Country dist.	
Scotland—	
Foundry No. 1	79/-
No. 3	76/6
Hem. M/Nos.	76/-
Sheffield (d/d district)—	
Derby forge	61/-
fdry. No. 3	66/-
Lincs. forge	—
fdry. No. 3	66/-
E.C. hematite	83/6
W.C. hematite	86/6
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	64/6
fdry. No. 3	69/6
Staffs foundry No. 3	69/6
Dalzell, No. 3 (special)	105/- to 107/6
Summerlee, No. 3	91/-
Glengarnock, No. 3	—
Eglinton, No. 3	91/-
Gartsherrie, No. 3	91/-
Monkland, No. 3	91/-
Shotts, No. 3	91/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	10	0	0 to	10	15	0
Nut and bolt iron	8	15	0 to	9	0	0
Hoops	10	15	0 to	12	0	0
Marked bars (Staffs) f.o.t.				12	10	0
Gas strip	10	15	0 to	12	0	0
Bolts and nuts, ¼ in. × 4 in.				14	5	0
Steel—						
Ship plates	8	15	0 to	8	17	6
Boiler plts.	9	7	6 to	10	5	0
Chequer plts.				10	12	6
Angles				8	7	6
Tees				9	7	6
Joists				8	10	0
Rounds and squares, 3 in. to 5½ in.				9	7	6
Rounds under 3 in. to ¼ in. (Untested)				7	12	6

and upwards

Flats—8 in. wide and over	£8 12 6
under 8 in. and over 5 in.	8 17 6
Rails, heavy	8 10 0
Fishplates	12 0 0
Hoops (Staffs)	£9 5 0 to 9 10 0
Black sheets, 24g.	8 12 6 to 9 12 6
Galv.cor.shts., 24g.	11 5 0
Galv fencing wire, 8g. plain	12 0 0
Billets, soft	5 12 6 to 6 5 0
Billets, hard	7 10 0 & up.
Sheet bars	5 0 0 to 5 12 6
Tin bars	5 0 0 to 5 12 6

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1/0½
Sheet to 10 w.g.	1/1
Wire	1/1½
Rods	1/1
Tubes	1/5½
Castings	1/0½

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2½ to 1/8¼
To 15 in. wide	1/2½ to 1/8½
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/4½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
3/0 to 10 G.	1/5½ to 2/0½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	17.76
No. 2 foundry, Valley	17.00
No. 2 foundry, Birm.	14.00
Basic	18.76
Bessemer	19.26
Malleable	19.26
Grey forge	18.76
Ferro-mang. 80%	94.00
O.-h. rails, h'y, at mill	43.00
Billets	31.00
Sheet bars	31.00
Wire rods	36.00
	Cents.
Iron bars, Phila.	2.09
Steel bars	1.60
Tank plates	1.60
Beams, etc.	1.60
Skelp, grooved steel	1.60
Skelp, sheared steel	1.70
Steel hoops	1.95
Sheets, black, No. 24	2.45
Sheets, galv., No. 24	2.95
Sheets, blue an'l'd, No. 13	2.05
Wire nails	1.90
Plain wire	2.30
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$5.00

COKE (at ovens).

Welsh foundry	25/- to 27/6
furnace	16/- to 18/-
Durham and Northumberland—	
foundry	15/- to 15/6
furnace	14/6
Midlands, foundry	—
furnace	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 box	15/9 to	16/-
"	28×20 "		31/6
"	20×10 "		23/-
"	18¾×14 "		16/6
C.W.	20×14 "		15/-
"	28×20 "		29/6
"	20×10 "		21/-
"	18¾×14 "		16/-
Terneplates	28×20		31/- per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0 to	£7	10	0
Bars, hammered, basis	£17	10	0 to	£18	10	0
Bars and nail-rods, rolled, basis	£15	17	6 to	£16	15	0
Blooms	£10	0	0 to	£12	0	0
Keg steel	£32	0	0 to	£33	0	0
Faggot steel	£20	0	0 to	£24	0	0
Bars and rods dead soft, steel	£11	0	0 to	£14	0	0

All per English ton, f.o.b. Gothenburg.

XUM

TUBES AND FITTINGS.

Over ½ in. up to 6 in.

	Tubes.	*Fittings.*
Gas	62½%	47½%
Water ..	58½%	42½%
Steam ..	55%	37½%

W.I. 12½% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Dec.	11 ..	46	1	3	dec.	11/3
,,	12 ..	45	7	6	,,	13/9
,,	15 ..	45	7	6	No	change
,,	16 ..	44	5	0	dec.	22/6

Electrolytic Copper.

		£	s.	d.		
Dec.	11 ..	50	0	0	No	change
,,	12 ..	49	0	0	dec.	20/-
,,	15 ..	48	0	0	,,	20/-
,,	16 ..	47	0	0	,,	20/-

Standard Tin (cash).

		£	s.	d.		
Dec.	11 ..	108	17	6	dec.	55/-
,,	12 ..	108	5	0	,,	12/6
,,	15 ..	106	12	6	,,	32/6
,,	16 ..	105	10	0	,,	22/6

Tin (English ingots).

		£	s.	d.		
Dec.	11 ..	110	0	0	dec.	55/-
,,	12 ..	109	7	6	,,	12/6
,,	15 ..	107	15	0	,,	32/6
,,	16 ..	106	10	0	,,	25/-

Zinc Sheets (English).

		£	s.	d.		
Dec.	11 ..	24	0	0	No	change
,,	12 ..	24	0	0	,,	,,
,,	15 ..	24	0	0	,,	,,
,,	16 ..	24	0	0	,,	,,

Spelter (ordinary).

		£	s.	d.		
Dec.	11 ..	13	15	0	dec.	1/3
,,	12 ..	13	12	6	,,	2/6
,,	15 ..	13	10	0	,,	2/6
,,	16 ..	13	6	3	,,	3/9

Lead (English).

		£	s.	d.		
Dec.	11 ..	16	15	0	dec.	5/-
,,	12 ..	16	10	0	,,	5/-
,,	15 ..	16	10	0	No	change
,,	16 ..	16	5	0	dec.	5/-

Imports and Exports of Iron Castings in November and the eleven months 1930, compared with November and the eleven months 1929.

	November, 1929.	November, 1930.	11 months, 1929.	11 months, 1930.	November, 1929.	November, 1930.	11 months, 1929.	11 months, 1930.
Imports.	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Pipes and Fittings, Cast	1,316	2,068	29,447	19,713	20,978	20,221	336,277	229,151
Castings, in the Rough, Iron	804	90	3,367	2,140	16,289	1,660	74,624	45,533
,, ,, ,, Steel	1,169	554	12,826	11,875	29,367	14,333	291,577	285,132
Hollow-ware, Cast, not Enamelled	17	2	48	37	1,762	240	4,508	3,783
,, ,, Enamelled	3	—	94	30	180	54	4,728	1,812
Exports.								
BUILDERS' CASTINGS—								
To Argentine Republic	185	45	1,816	1,677	5,922	1,606	81,309	74,914
,, British South Africa	430	251	3,316	2,356	15,569	9,938	119,567	91,654
,, ,, India	193	135	1,569	1,434	8,555	5,140	63,164	52,413
,, Australia	75	1	697	253	4,578	178	40,711	14,676
,, New Zealand	148	92	1,323	922	8,618	5,833	80,819	54,304
Total (including other countries)	2,262	1,606	18,498	16,394	100,414	69,448	835,249	725,565
PIPES AND FITTINGS—CAST—								
To Argentine Republic	1,820	571	22,838	13,934	17,478	5,751	213,890	138,039
,, British South Africa	1,147	1,224	7,407	9,812	11,963	13,540	90,927	105,006
,, ,, India	362	189	3,902	2,709	4,462	2,625	53,607	40,757
,, Straits Settlements and Malay States	1,079	1,236	19,055	10,556	9,963	9,915	143,087	91,351
,, Ceylon	138	63	2,061	1,381	1,350	778	20,706	14,691
,, Australia	386	115	3,478	748	5,327	2,160	41,155	13,914
Total (including other countries)	13,629	9,456	125,088	110,596	141,317	102,526	1,337,466	1,220,293
HOLLOW-WARE—								
Cast, not Enamelled, and Cast, Tinned	546	292	4,533	3,691	19,666	9,670	161,256	121,258
,, Enamelled	82	61	884	761	7,607	5,630	79,126	65,565
CASTINGS, IN THE ROUGH—								
Iron	108	274	1,396	2,169	4,591	5,821	51,400	65,582
Steel	245	121	1,375	1,872	9,605	5,760	54,478	78,453

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THE Directors of this Company are prepared to receive Tenders for the supply of the undermentioned Iron and Steel Goods:—

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3.—Tyres and Rolled-Steel Wheel Centres.
4.—Steel Axles and Forgings.
5.—Iron Plates and Bars.
6.—Steel Plates and Sheets.
7.—Steel Bars and Blooms.
8.—Steel Castings (Wheel Centres).
9.— ,, (Miscellaneous).
11.—Chain and Iron for Chain Manufacture.
12.—Tubes and Fittings (Gas, Steam, Electric Conduit, etc.).
13.—Weldless Steel Tubes (Boiler, Steam and H.P. Gas, etc.).
14.—Cast-Iron Socket, etc., Pipes and Iron Castings.
15.—Galvanised Sheets.

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F. R. E. DAVIS,
Secretary.

Paddington Station, London, W.2,
December 16, 1930.

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'Phone: 287 SLOUGH

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2 Britannia No. 1 jolters, each	£36
1 Macdonald 24"×20" electric turnover	£40
1 Macdonald 24"×20" pneumatic turnover	£40
1 "Grimes" 36"×24" pneumatic turnover	£40
1 "Tabor" 40"×30" "Shockless" turnover	£130
1 "Tabor" 50"×42" "Shockless" plain jolt	£70
1 "Shockless" 72"×60" plain jolter	£90
4 Adaptable machines, standard type	£14

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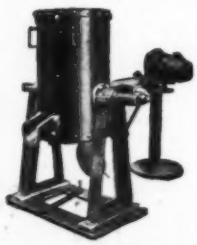

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